CMC 2010

Concept Maps: Making Learning Meaningful

Proceedings of the Fourth International Conference on Concept Mapping

Jaime Sánchez I
Alberto J. Cañas
Joseph D. Novak
Editors



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Viña del Mar, Chile

Volume 1

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MAKING LEARNING MEANINGFUL

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4

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Preface

Welcome to CMC 2010, the Fourth International Conference on Concept Mapping, and to Viña del Mar, Chile.

Since 2002 a growing concept mapping community throughout the world meets every two years to share and exchange research and practice experiences. This new version of CMC provides a new opportunity to expand and deepen the scope of concept mapping applications and developments.

The international Program Committee has carefully selected 52 quality full papers, 57 poster short papers and 14 posters with abstracts. As a result, CMC 2010 encloses a strong program covering an ample variety of topics from researchers and practitioners coming from twenty five countries.

The conference is also enriched with the participation of distinguished keynote speakers and theme panelists that will create exchange and discussion of ideas and experiences.

Finally, the Local Organization Committee has done an exceptional job to make this event come true and taking care of all details to make the participants and guests feel at home, and the Universidad de Chile has made a huge effort to make sure the Conference is a great success.

Jaime Sánchez, Chair CMC 2010
Alberto J. Cañas, Co-Chair CMC 2010

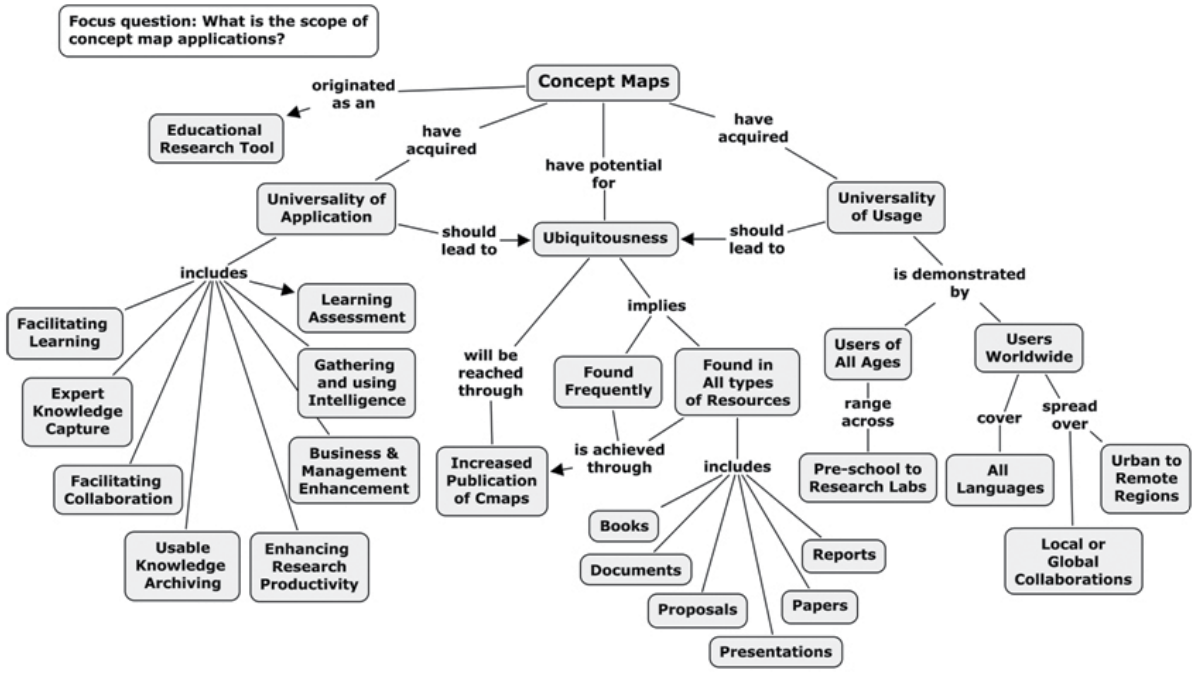
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THE UNIVERSALITY AND UBIQUITOUSNESS OF CONCEPT MAPS

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www.ihmc.us



1 Introduction: The Origins and Evolution of the Concept Mapping Tool [1]

The concept map was developed as a response to the necessity by Novak's research group at Cornell University in the early 1970s to find a better way to represent children's conceptual understandings and to be able to observe explicit changes in the concept and propositional structures that construct those understandings, as part of a 12-year longitudinal study following a 2-year instructional period using audio-tutorial instruction in grades one and two (Novak, 1972). The research program was based on Ausubel's (1963, 1968) Assimilation Theory of cognitive learning, and an emerging constructivist epistemology that viewed knowledge as a human creation involving the construction on new concepts and propositions through the process of high levels of meaningful learning, as described by Ausubel, and Novak's Human Constructivist epistemology (Novak, 1993, 1998). While we found structured interviews to be useful in capturing children's understanding, it was difficult to discern specific changes in the children's concept and propositional ideas as they progressed through schooling. Working with a talented group of graduate students, Novak and his colleagues came up with the idea of transforming interview transcripts into a hierarchically arranged set of concepts and propositions representing the knowledge expressed in the interview. Mapping a child's interview transcript often revealed ambiguities not seen previously that required more careful listening to the interview tape to discern additional

[1]For a description of the origins of concept mapping see Novak & Cañas (2006).

cues for the child's thinking. Thus was born the concept map tool for representing human knowledge.

1.1 Expansion of the Use of Concept Maps in Education

Graduate students in Novak's research group soon discovered that concept maps were not only useful to transcribe the children's' interviews, but helped them become better learners. It became increasingly apparent that *meaningful learning was the most important factor in building powerful knowledge structures*, and by contrast, learning by rote contributed little to building individual's knowledge structures, nor does rote learning result in the remediation of misconceptions held by learners. Novak found that the use of concept maps could help students *learn how to learn meaningfully*, and taught a course at Cornell University for 20 years to help students become better learners. This course led to the book, *Learning How to Learn* (Novak & Gowin, 1984) now published in 9 languages.

During the 1980s concept mapping's popularity flourished particularly within the education community, in conjunction with Ausubel's Assimilation Theory. Concept maps became a popular assessment tool, from elementary school to graduate courses. However, concept maps were mainly drawn on paper by hand, which limited their use since it would take a big effort to redo concept maps, and so they were seldom redrawn. The potential of the concept mapping tool was not yet fully realized.

1.2 Concept Mapping meets the Internet & Corporations

Advances in graphical user interfaces and technologies in the 1990's allowed the development of computer-based concept mapping editors. But it was the development of concept mapping tools, such as CmapTools (Cañas, Hill, et al., 2004), that leveraged the Web, multimedia and Internet that further expanded the use of concept mapping, not only in terms of users but also the types of applications to which it applied and organizations that use it. These new tools enabled the collaborative construction of concept maps, and publishing and sharing of concept maps on the Web. The ability to easily link concept maps to other concept maps, and link different types of resources (images, videos, texts, Web pages, etc.) to the maps allowed the construction of Knowledge Models (Cañas, et al., 2005) enabling the representation of more complex domains and the development of a concept map-centered learning environment: a New Model for education (Novak & Cañas, 2004).



Figure 1. CmapTools users throughout the world.

In the 1990's, Novak worked with R&D staff at Procter and Gamble and found that concept mapping not only facilitated better organization of research team's knowledge, but also facilitated creative work by the team. These works are summarized in Learning, Creating, and Using Knowledge: Concept maps as Facilitative Tools in Schools and Corporations (Novak, 1998). In all of this work the most fundamental idea is that meaningful learning not only helps learners acquire more powerful knowledge structures, but it is also the means for the creation of new knowledge.

The 2000's have seen a continuous growth in the use of concept mapping and in its applications. This growth is reflected in the extensive participation and wide-ranging topics presented at the Concept Mapping Conferences (Cañas & Novak, 2006a; Cañas, Novak, & González, 2004; Cañas, Reiska, Åhlberg, & Novak, 2008) and in the active Cmappers community (the informal community of concept mappers around the world). Figure 1 shows how CmapTools users connecting to CmapServers cover large portions of the world.

2 The Universality of Concept Mapping

We know of no domain of knowledge where concept mapping cannot be applied, and continue to find new applications for the tool. In addition to the early use for assessing growth in conceptual understanding and helping students learn meaningfully, numerous other applications have appeared in the last 30 years, and it is likely that additional useful applications will be found for this tool in the future. We sketch below examples of some of the newer applications for the concept map tool.

2.1 Facilitating Meaningful Learning

Given its roots described above, it is not surprising that the most prevalent application of concept mapping is in facilitating meaningful learning. Figure 2 shows a graph of the number of downloads of CmapTools from the IHMC download Website (there are other means of obtaining the software which we have been encouraging lately, so this doesn't show the total number of users). In addition to showing the growth in number of downloads throughout the years, the graph also clearly depicts the peaks in downloads during the months of February, March, August and September, when the school year begins in the Southern and Northern Hemispheres, and valleys when most schools and universities are on vacation (July and December). Clearly education seems to continue to be the main application of concept mapping.

In the Epigraph to his 1968 and 1978 books, Ausubel (1968; 1978) states:

If I had to reduce all of educational psychology to just one principle, I would say this: The most important single factor influencing learning is what the learner already knows, Ascertain this and teach him accordingly.

Simple as this may appear, it is profoundly difficult to ascertain precisely what a person already knows. In fact, it was this problem that led us to the development of the concept map tool, as noted above. While it is difficult to assess what an individual knows about a given topic or problem, it is even more difficult to assess precisely what a study team or group knows. Here again we have found concept maps to be an expedient and effective tool. We have also found it very important to define carefully the problem or issue to be addressed and to construct carefully a "focus question" to guide the knowledge elicitation process. There is an iterative process between designing a focus question, soliciting or searching for relevant knowledge, concept mapping that knowledge, and then perhaps refining the focus question or asking more questions (Cañas & Novak, 2006b; Chacón, 2006) that has proven to be very effective. This iterative process, supported with the tools provided by CmapTools such as collaboration and searching for information relative to a concept map, has lead to the concept-map based learning environment's New Model of Education (Novak & Cañas, 2004). When concept maps are used as pretests and then employed with new learning materials, research has shown that meaningful learning can be much facilitated (Al-Kunifred & Wandersee, 1990; Novak & Gowin, 1984; Novak & Wandersee, 1990).

The use of concept maps within education varies widely, from schools which have adopted our ideas and use concept maps and CmapTools in all subjects and grades with extraordinary results like the Instituto de Educación Integral in Costa Rica (Silesky & Badilla, 2008), to efforts to introduce concept mapping into public schools at a country-wide level (Tarté, 2006) or having CmapTools installed in all computers delivered to schools for a whole region (Garcia, 2010), but unfortunately also includes teachers that give the students pre-built concept maps to memorize, or partially filled concept maps to "fill-in-the-blanks". Overall, we have found that there is room for improvement to take advantage of concept mapping's full potential (Cañas & Novak, 2006b). However, it is clear that concept maps are useful, and are being used, from pre-school to graduate school, research groups, corporate learning and lifelong learning, and in any subject matter area.

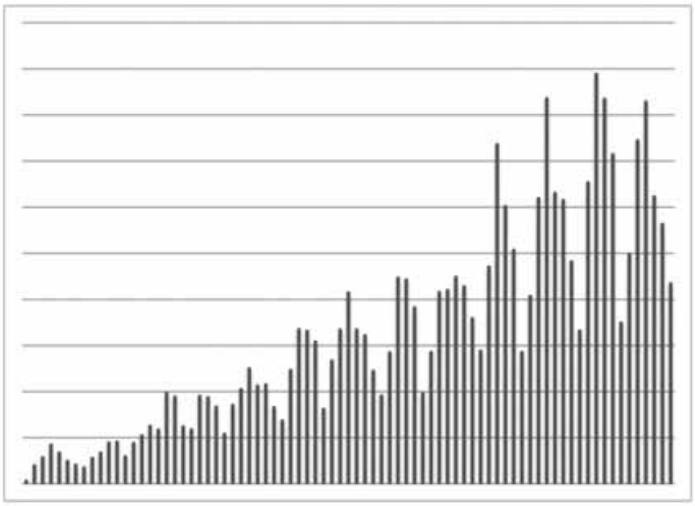


Figure 2. Monthly downloads for CmapTools show peaks when classes begin in the Northern and Southern Hemisphere, and valleys when schools and universities are on vacation.

As examples we proceed to present some uses and subject areas, without any intention of being complete or extensive, as most of the application in schools and universities is not reported in the literature. References are samples of use, not comprehensive reports on each area.

Concept mapping has been shown to be effective when used as an assessment tool (Fischler, et al., 2002; McGaghie, McCrimmon, Thompson, Ravitch, & Mitchell, 2000; Reiska, 2005; West, Pomeroy, Park, Gerstenberger, & Sandoval, 2000) at all levels of education. When used with pre-school or elementary school children, they also facilitate language learning and learning to read as well better ways to learn (Beirute, Brenes, Cortés, García, & Meza, 2006; Cassata-Widera, 2009; Mancinelli, 2006). Elementary (primary) education is probably the educational level where concept mapping is most popular and has received more attention in terms of its effectiveness, with less reports found on use at the secondary/high school level. At all educational levels, science seems to be the subject where concept mapping is applied the most (Heinze-Fry, 2004; Novak & Wandersee, 1990). Concept mapping has been used less in mathematics, but within the last few years we have seen an increase it its use as reported in Afamasaga-Fuata'i (2009). Additionally, concept mapping has been applied to reading comprehension (Conlon, 2008; Iraizoz Sanzol & González, 2003) writing (Straubel, 2006), learning foreign languages (Bahr & Dansereau, 2001; Marriott & Torres, 2008), as well as social studies (Chatterjea, 2008; Trygestad, 1997). At the college level, concept mapping is used in a large variety or programs, including engineering (Darmofal, 2002; Walker & King, 2002), nursing (Daley, 1996), biology (Henno & Reiska, 2008; Kinchin, 2000; Trifone, 2006), chemistry (Shanze & Grüss-Niehaus, 2008), physics (Pérez, Suero, Montanero, & Pardo, 2004), medicine (Brüchner & Sascha Schanze, 2004; Daley, et al., 2006), veterinary (Edmondson & Smith, 1996), psychology (Carnot & Stewart, 2006), vocational education (Reiska & Ruohotie, 2008), business schools (Leauby & Brazina, 1998; Simon, 2007) and of course Schools of Education (Himangshu, Iuli, & Venn, 2008) among others, and we have seen large collections of concept maps used in the learning of physical education, sports and music and art. Additionally, concept mapping facilitates the integration of different curriculum subjects. At the graduate level, success is reported in the use of concept mapping within research programs (Markham, Mintzes, & Jones, 1994; Okada, 2008; Wallace & Mintzes, 1990). Training programs at organizations and corporations have also benefited from the use of concept mapping (Bowen & Meyer, 2008; Trujillo, 2008).

Concept mapping is also used within the education community for curriculum development (Edmondson, 1995; Heinze-Fry & Ludwig, 2006; Riesco, Fondón, & Álvarez, 2008). Across ages and subjects, concept mapping has been proven to be an effective tool to engage students in collaboration and collaborative projects (Basque & Lavoie, 2006; Tifi & Lombardi, 2006; Torres & Marriott, 2010) as well as for distance learning (Dutra, Fagundes, & Cañas, 2004) and organizing learning content (Kumar & Saigal, 2005). Concept mapping has been used with dyslexic students

(Lami & Locatelli, 2008), students with hearing impairments (Peña, Bernal, & López, 2008), blind students (Sánchez & Flores, 2010) and autistic children (Roberts & Joiner, 2007). Additionally, we have seen concept maps created by home-schoolers in the IHMC CmapServers. For lack of space we won't go into the numerous activities in the classroom that can be supported through concept mapping.

It is clear that concept mapping has had a large impact on students, teachers, and educational systems all over the world.

2.2 Knowledge Management

Much of the funding at the Institute for Human and Machine Cognition (IHMC) for the development of CmapTools came from US federal agencies who saw value in the use of concept maps to capture and archive expert knowledge in a form that would be easy to use by others. In a sense, eliciting the knowledge from an expert and representing it in such a way that its easily understood is not much different from assessing the knowledge of a school-age student. Thus, the same tools and software are used to graphically express the knowledge of elementary school children and of world-class experts.

These efforts have resulted in several projects, both at IHMC and by others, that show the feasibility of using concept maps to capture and archive knowledge. The first such effort was NUCES (Ford, Coffey, Cañas, Andrews, & Turner, 1996), an expert system to aid in the diagnosis of heart diseases. Other such systems, based on knowledge engineers interviewing experts (Coffey & Hoffman, 2003) include El-Tech, which demonstrated the approach was feasible with Navy technicians (Coffey, et al., 2003), STORM-LK, which modeled weather forecasting in the Gulf of Mexico (Hoffman, Coffey, Ford, & Novak, 2006), and projects with power plant engineers (Coffey, Eskridge, & Sanchez, 2004), among others. Concept mapping as a tool for knowledge elicitation has since been used by other organizations, including the Electrical Power Research Institute (EPRI, 2007; Hanes & Ziebell, 2004). Barbara Bowen of Sound Knowledge Strategies reports on the use of concept maps for team knowledge elicitation at public health agency (Bowen, 2010) and Preciado et al. (2008) report on the use in the design of a competitiveness system. Beyond knowledge elicitation, concept mapping's use in organization has spread within other areas of knowledge management, as reported by Henao et al. (2007) and Basque et al. (2004). Its important to note that eliciting knowledge is not limited to professional or science experts. At the request of the Queen of Thailand, Hoffman and his colleagues at IHMC prepared a prototype Knowledge Model dealing with Thai fabric design and creation. Thailand has a long history of leadership in this area, many of its craftsmen are reaching old age, and the Queen wanted to preserve this knowledge.

2.3 Other Business Applications

Beyond Knowledge Management, corporations and organizations worldwide are using concept mapping. Unfortunately most of them are reluctant to share their experience and so reports of their use come from the academic community or through informal communications. For example, Fourie & Westhuizen (2008) write on the use of concept mapping for strategic alignment, Kyrö & Niskanen (2008) on the use in business planning, and Dumestre (2004) on performing job task analysis. Concept mapping has been known to be used for requirements elicitation and specification (Freeman, 2004) both during the development of computer system and for the requisition and purchasing. This application is in line with the use reported by consultants where they use concept maps as a means to agree with their customers on statements of work.

Concept maps have been reported to be used for project management, including project proposals and project reports (Ramírez, Flores, & Barros, 2008). At IHMC we use concept mapping as a tool for capturing the results of Blue Sky-type brainstorm and innovation meetings and as means to prepare the resulting reports, and we are aware of their use for brainstorming and minute-taking at meetings in many organizations. In a similar application, concept maps have been used to document software development and products.

Intelligence organizations in several countries use concept mapping as a tool in social networking, to keep track of relationships between individuals, their locations, actions, contacts, etc. Unfortunately this use is classified. An analogous use is that of investigative reporting by journalists, where concept mapping is used to track the information about a case being investigated, keeping all journalists up-to-date, and for detecting missing links in the information.

Other business applications have included the combination of concept maps or CmapTools with other software as part of a larger system. Typical of this application is the use of concept maps as part of ontology or thesaurus generation, where concept maps are used as a friendlier interface for users than the formal representation of an ontology. Another such application is the combination of CmapTools with proprietary software developed by MedTrack to provide Electronic Medical Records (EMR) that contain essential information for a given patient that are complete and cover all aspects of the patient's medical history and aftercare instructions (Helfgott, Brewer, Novak, & Schanhals, 2010). Business applications of concept mapping are more prevalent than what the literature tends to show. Moon et al. (to appear, 2010) contains additional applications of concept maps in organizations and businesses.

2.4 Organizing & Navigating through Information

Concept maps have been known to be an effective tool to organize and navigate through large volumes of information (Carnot, Dunn, Cañas, Graham, & Muldoon, 2001), and there are quite a few sites that use them for this purpose. Perhaps the most extensive of such efforts was work done by Geoff Briggs at NASA Ames Research Center to create an extensive knowledge model consisting of over 300 concept maps dealing with Mars and Mars exploration (Briggs, et al., 2004), and which has extended to the rest of the Solar System. With a similar purpose, concept maps have been used as a tool to design Websites.

Beirute & Mayorga (2004) have used concept mapping for conflict resolution, and Fraser (1993) found that concept maps prepared by workers in computer sales, when shared between workers who had conflicts, quickly resolved the conflicts, and this improvement in cooperation continued. This list of applications is by no means exhaustive. There are personal uses of concept maps, such as planning a vacation, which we run into all the time through personal communications or just by browsing through the CmapServers, as well as other educational, business, and corporate uses. We have no doubt of the universality of the application of concept mapping.

3 On the Ubiquitousness of Concept Maps

Kinchin (2001) has asked why aren't we all using concept mapping in the classroom, if they are so helpful. At the closing session in Helsinki at CMC2008, the Third International Conference on Concept Mapping, Tom Conlon questioned how many more papers we need to write showing positive results of the use of concept mapping in different educational settings before we see a broader use of the tool in schools, and proposed that we ask ourselves what needs to change (in the tool? in existing software?) before concept mapping is used more extensively.

We would like to broaden these questions to concept mapping in general. If concept maps are applicable to so many domains and are used by people of all ages, why is it that we don't "run into" concept maps more often? We could argue that at any point in time, somebody somewhere in the world is busy constructing a concept map.[2]The index of searchable concept maps at www.Cmappers.net is up to around 400,000 maps that have been made public. Although this seems like a large number, it's actually small compared to the total number of concept maps being built using CmapTools. Browsing through these Cmaps shows that many of them are "test" maps, and a good portion are maps constructed during workshops, practice maps, many of them incomplete. And although there are a large number of well constructed, relevant, and interesting Cmaps, there should be more of them.[3]Apparently we keep our good Cmaps to ourselves. Its understandable that a number of Cmaps within corporations need to be kept private, but given

[2] Based on the logs of public CmapServers at IHMC, where we can observe the rate at which Cmaps are being saved using CmapTools.
[3]The Cmappers search only retrieves Cmaps with a high topological taxonomy value, assuming these maps will be of higher interest.

the number of concept mappers worldwide, its likely there are a lot of good concept maps that are not being shared and could be of use to others.

We should be seeing concept maps as explanations (illustrations) in books, papers, reports, proposals, presentations, Websites, and all types of documents. However, we seldom find concept maps as explanations in documents, we mostly find concept maps as examples in papers about concept mapping; and even within these papers we don't find concept maps as summaries or explanations of the paper itself. If we believe concept maps are good for communicating ideas, why don't we see more concept map-based presentations at the Concept Mapping Conferences?

When textbooks make reference to concept mapping, they mostly provide exercises consisting of a concept map with some blank labels for some concepts for students to fill-in the blanks, which is probably one of the worse uses of concept maps in the classroom.[4]Textbook exercises don't use concept maps as a means of integrating content, building on a set of concept maps as the student progresses through the chapters.

It seems that Cmappers are not using concept maps for "communicating" or sharing their knowledge. There may be several reasons for this. First, people may not be very secure about their concept maps, and even though they may be building them when preparing documents, reports, etc., they prefer not to include them in their final work. Second, users may use concept mapping as a way to organize their thoughts but never "finalize" their concept maps to the point where they can be published. Third, the technology available may not be flexible enough to make the concept maps more ubiquitous. Even though software like CmapTools make it easy to export Cmaps as images, PDFs, or Web pages, and to publish them on the Web, the integration into popular software packages like Microsoft Office, Wikis, Blogs, Facebook and Moodle might increase their visibility. Last, constructing concept maps is not easy – it requires effort to build a good map, which may lead to users opting not to build concept maps because of the time required.

As an initial step, we propose that the papers submitted to future Concept Mapping Conferences should include a concept map instead of a text Abstract. We have begun by including a Cmap in lieu of an Abstract in this paper.

We encourage the Cmappers community to be more forthcoming in the use of concept maps. The universality of the application provides numerous opportunities to use the concept maps, and showing the use of the tool through good concept maps is a way of educating the general public on its use.

4 Summary

The examples given above illustrate some of the broad range of activities related to learning, creating, and using knowledge for which concept maps can serve a useful, productive, and facilitative role (Novak, 1998, 2010). Over the years it has been demonstrated that concept maps can be used from pre-school to research laboratories and corporations for any subject matter. Each year we see new applications of this tool and new possibilities that need to be explored. Bush (1945) characterized science as an endless frontier. We see applications for the concept map tool as also an endless frontier.

Regarding the lack of ubiquitousness of concept maps, one could see the current status as encouraging or discouraging. Considering the humble beginnings for the use of this tool to monitor changes in children's understanding of basic science concepts to the many application we report here, one could conclude that great progress has been made. However, when one looks at all the human activities that deal with knowledge that could benefit from the use of this tool, the percentage of the world population employing the tools is small. There is much work to be done to "spread the word" and we invite all readers to join in this effort.

[4]When Cañas met with a textbook publisher to explain why these type of exercises were not recommended, the publisher indicated they understood. Instead of changing the exercises they changed the term "concept map" for "map" and the exercises appeared in the next printing.

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ANALYSIS OF A GOLD STANDARD FOR CONCEPT MAP MINING – HOW HUMANS SUMMARIZE TEXT USING CONCEPT MAPS

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Abstract. Essay writing is an important learning activity which involves higher level thinking, the same as concept mapping activities.

1 Introduction

Essay writing is a common requirement for students in higher education due to the higher level thinking required to write essays (Paltridge 2004). Academic writing is an iterative process of writing and revision in which new version improves the final outcome. During revisions the author reflects on his own work and ideas, requiring analysis, argument and independent thought (Emig 1977). However, students can find this reflective thinking activity as hard to engage if it lacks the proper support. Concept mapping also requires higher level thinking from the students for them to build good quality concept maps (Novak and Gowin 1984). A good concept map contains only relevant concepts (a perceived regularity in events or objects, or records of events or objects, designated by a label), connected by linking words into coherent propositions. On deciding what concepts to include in a concept map, and on linking them properly the author's reflection is required (Novak 2007).

Concept maps have been used to support reading and writing activities, what is known as Text Concept Mapping (TCM) (Nurit Nathan 2004). The activities usually consist on summarizing the key ideas in a piece of text, and there are three ways of doing it: Building a concept map from scratch, fixing a previously built concept map and studying a concept map. In the first activity the students build a concept map without any support, in the second activity the teacher builds a map that has some errors and/or missing information that the students have to fix, and in the final activity the students study a concept map built by the teacher which summarizes the text. All activities have been shown to improve the students' understanding on the readings' topics (en Chang, Sung et al. 2002; Hauser, Nuckles et al. 2006).

TCM could be used to support the author's reflection during the writing process, particularly analyzing a concept map of their own work which represents a new visualization of the ideas expressed in their text (Villalon, Kearney et al. 2008). However concept mapping is highly time consuming, therefore having someone to build a concept map from each essay would become a bottleneck that will prevent the feedback to be delivered in a timely fashion, becoming an obstacle during the writing process. This problem could be solved by the automatic extraction of concept maps from student produced text, known as Concept Map Mining (CMM)(Villalon and Calvo 2008).

CMM has been proposed before for several applications such as overcoming the large amount of available data (Valerio and Leake 2006), to facilitate the organization of information in digital libraries (Shen, Richardson et al. 2005), and as a previous step to build domain ontologies (Zouaq and Nkambou 2008). In the context of essay writing, automatic concept maps can be used either to facilitate the construction for teachers or to present them to the author as a raw version they have to fix. In both cases the feedback could be given rapidly so the writing process is not interrupted. However, CMM is still a work in progress, which requires several steps in order to achieve its goal (Villalon and Calvo 2009).

The biggest challenge in CMM is the highly subjective task of evaluating if a concept map correctly summarizes an essay. In order to gain a better understanding of it, first one must have to understand how humans perform the task, so interesting patterns can be analyzed and then inform the design of an automatic process. Such understanding is gai

ned through the construction of a gold standard, which corresponds to concept maps extracted from essays by at least two human annotators, following the same procedure. This collection of concept maps defines a 'gold standard' for the CMM process, and any automatic procedure should aim to extract maps that are equivalent to those in it (Villalon and Calvo 2008).

This paper presents an analysis of a gold standard constructed to evaluate CMM algorithms. Such a gold standard represents a new visual representation of the knowledge expressed in the text in the form of concept maps, and carries a lot of information on how humans respond to the task of summarizing someone else's text into a concept map, particularly students' essays which have several other complexities (grammatical and spelling errors). The analysis tries to answer the question on "How humans summarize knowledge from text using concept maps?" It is structured as follows: Section 2 presents a summary on what CMM is. Section 3 reports on the process of building the gold standard. Section 4 presents an extensive analysis on the produced maps and section 5 concludes.

2 Concept Map Mining

Concept Map Mining is defined as the automatic extraction of concept maps from text that are useful in educational contexts. Its aim is to provide new ways to visualize the knowledge expressed in the text for human consumption. It focuses on the use of concept maps to support writing activities in educational scenarios, which poses several challenges to the task that are summarized in four requirements for automatic concept maps: Educational utility, simplicity, semi-formality and subjectivity. Educational utility refers to the structure required for an automatic concept map which has to be the same as the one proposed by Novak (Novak 2007), otherwise their benefit as educational tools can be questioned. Simplicity refers to the fact that the automatic concept map has to be a reduced version of the text, otherwise it may require the same effort as reading the text. Semi-formality refers to the computational representation of the concept map, which has to be structured enough so they can be processed as digital concept maps can be. Finally, subjectivity refers to the fact that the knowledge represented in the automatic concept map has to be faithful to the written essay, and not to be influenced by external knowledge.

The CMM process consists on identifying the key concepts in a piece of text and the linking words that connect them. It has three sub-tasks which are: Concept Extraction, Relationship Extraction and Summarization. The first task aims to identify every possible concept in the text, the second aims to find all possible connections between the previous concepts and the third step consists on creating a reduced version of the map that summarizes the content, avoiding redundancy and maximizing coverage. Figure 1 shows a scheme that summarizes the process.

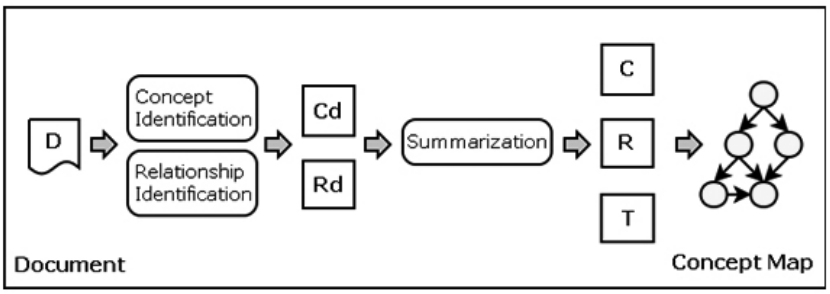


Figure 1. The CMM process

Ontology Learning from Text is an area that is related to CMM in the same way Ontologies are related to concept maps, both have structural similarities however they differ in their goals and therefore in their methods. Ontologies are knowledge representations that also comprise concepts linked by meaningful relationships, making the structurally similar to concept maps. However, ontologies reflect a shared knowledge which is the consensus of a set of experts, while concept maps can reflect the knowledge of any person, particularly non experts which can be highly subjective

and incomplete. As a consequence concept maps can contain information that could hardly be used in an ontology, but at the same time it is highly useful in educational scenarios (identifying misconceptions and/or mistakes).

3 Gold Standard

The annotation of a gold standard is a common requirement for the evaluation of knowledge extraction algorithms (Wiebe, Bruce et al. 1999; Dellschaft and Staab 2006). This is due to the highly subjective nature of knowledge, which requires humans to evaluate what can be considered relevant knowledge and what should not. In other words, the correct answer to a highly subjective question such as "What is the concept map that summarizes a text?" can be answered only by humans. Moreover, it is acknowledged that this subjectivity will not be assessed equally among different human subjects, therefore the answer will be as good as the one shared by most humans (Carletta 1996). In terms of a gold standard for CMM, this means that several human annotators must extract concept maps from the same collection of essays.

Every gold standard requires an annotation procedure that has to be clearly defined, and supported by tools. The procedure used for the gold standard analyzed in this paper was originally written following Novak's suggestions on how to build good concept maps, and then refined by consecutive iterations of the annotators performing it. The procedure was also supported using an annotation tool that checked the consistency of the annotations. Figure 2 shows the interface of the annotation tool, which presents the essay on the left side of the screen, the concepts selected in the previous step (Concept extraction), than can be linked with another concept in the map using linking words that can be freely added.

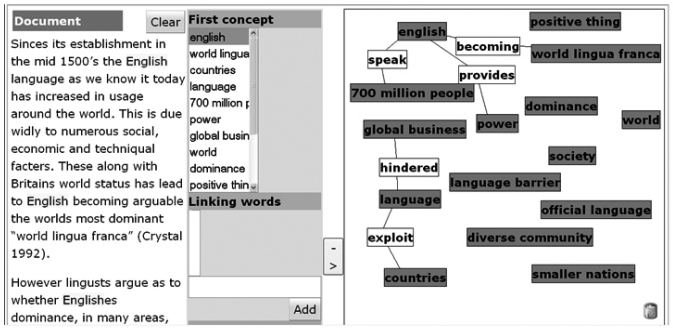


Figure 2. Interface of the annotation tool.

The gold standard was built from a collection of 42 essays written by first year university students. The annotation was done by five human annotators that had previous experience as concept mappers. Three of the annotators had less experience, they were chosen to perform a preliminary annotation to improve the procedure and the last two produced the final version. The first iteration of the annotation process showed that most humans used external information that was not necessarily expressed in the text, although it was common sense to infer the author's intention. This lead to force that the concepts should appear with the linking word within a text passage, in this case a paragraph was defined. The resultant gold standard contains 42 concept maps, totaling 877 concepts and 516 relationships, and took an average of 27 minutes per essay.

4 Analysis

The analysis of a gold standard looks to answer questions that enlighten the understanding on how people perform a highly subjective task such as building concept maps from text. These questions can be classified depending on different aspects of concept maps and text.

- Coverage: How many concepts annotators use to summarize an essay? How many relationships? Is it related to the length of the text? Is it related to its quality?
- Concepts: Are they chosen according to linguistic characteristics such as their part of speech? Are they chosen due to statistical characteristics such as the frequency with which they appear?
- Relationships: Are there common linguistic characteristics to linking words? Are concepts chosen mostly within sentences or paragraphs? Does the sequence presented in the concept map reflect the same sequence in the text?

The answers to these questions provide important evidence on the patterns humans use when creating concept maps from text, which represent the core information for the construction of automatic algorithms. On identifying interesting patterns, suitable techniques to identify such patterns should provide the best possibility for automatic extraction.

4.1 Coverage

When asking humans to summarize a piece of text, a reduced version of it is produced. For example in automatic summarization processes a percentage of the original content, measured in words, sentences or paragraphs. But what happens when a concept map is the new representation? Is it related to its length? Is it related to its quality? In order to analyze this, the length of the essays was calculated in words and sentences. The total number of concepts and relationships used by the annotators was also computed and the correlation between these values is shown in Table 1.

Correlations	Average number of Concepts	Average number of Relationships
Length in words	0.62	0.38
Length in sentences	0.52	0.30
Grades	**0.28**	**0.14**

Table 1. Correlation between the size of concept maps, the length of the essays and their grades.

Several conclusions can be made from the table above, firstly that the length of the essay has a positive correlation with the number of concepts in a concept map, longer essays will be summarized using more concepts. However, the number of connections between those concepts has a significantly lower correlation, indicating that a longer essay doesn't necessarily mean a denser concept map. Finally, the last row in the table shows that the correlation between the grades (that represent to some extent the quality of the essay) and the number of concepts and relationships is very low. This last observation means that when the annotators were asked to summarize the content reflecting the ideas expressed in the essay, regardless of their own knowledge or external information on the essay's subject matter, they will select concepts and relationships making sure they cover the information in them.

4.2 Concepts

Novak proposed a definition of concepts: "A perceived regularity in events or objects, or records of events or objects, designated by a label". This definition is closely related to what is known in linguistics as "nouns", therefore it can be expected that the concepts chosen by the annotators to share such characteristic. Linking words on the other hand are supposed to form "meaningful propositions", however this definition is very subjective therefore there are no obvious linguistic characteristics that can be associated to meaning.

To assess the expected notions on the words or phrases chosen by the humans for concepts and relationships, each text was analyzed using a grammatical parser in order to identify each phrase linguistic characteristic, particularly their part of speech. Figure 3 shows the relative frequency of the parts of speech for concepts, the graph shows that more than 80% of them correspond to noun phrases, validating the closely related definitions of nouns and concepts. This is highly relevant for CMM because such characteristic (this is, a word or phrase being a noun or noun phrase) indicates a very high probability that the concept should go into the final concept map.

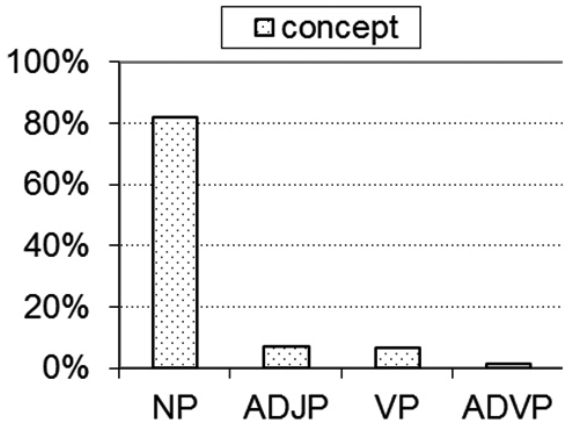


Figure 3. Part of speech for concepts.

Another pattern that can be calculated automatically for phrases and words in documents are their frequencies. In research areas such as keyword extraction and automatic summarization, the frequency of words can be used to identify relevant ideas. In order to validate or refute this idea, the frequency of every concept and relationship within each essay was calculated. Such frequencies represent a distribution that can be highly skewed if a few concepts appear several times while the others appear only a few times, follow a normal distribution if a majority of concepts share an average frequency, or have a uniform distribution if most concepts have a similar frequency.

Figure 4 shows an example of the concepts' distribution for an essay, which is highly skewed with concepts like English or language appearing more than 10 times, while diplomacy or the internet appear only once or twice. The Kurtosis measure of "peakedness" was used to calculate the distributions of concepts and relationships for each concept map, this measure goes between -1.2 for uniform distributions, 0 for normal distributions to 3 or higher for highly skewed distributions. Table 2 shows the results, indicating that both concepts and relationships are highly skewed with Kurtosis measures of 6.06 and 2.07 respectively. This result indicates that only a few concepts appear several times in an essay, but the majority appears only a few times.

One possible explanation for the highly skewed distributions is that some concepts are chosen due to their importance within the essay, but others by a different reason, like forming meaningful propositions with the important concepts. This behavior has been observed before and it is known as the Zipf's law, which indicates that only a few terms count for the most common utterances in any piece of text. This might mean that summarizing text using Concept Maps shows a similar behavior on choosing words as that of writing text from scratch. In order to validate if this behavior is such, a deeper analysis on the relationships is necessary.

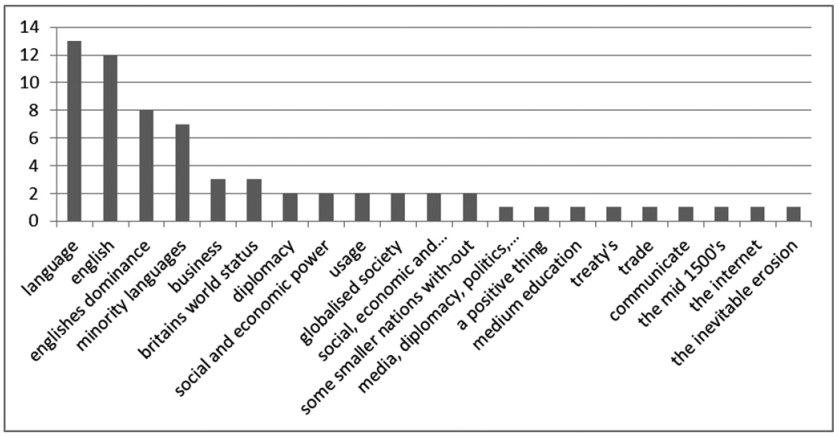


Figure 4. Sample distribution of concepts within an essay.

	Average Kurtosis
Concepts distribution	6.06
Relationships distribution	2.07

Table 2. Average Kurtosis measure for concepts and relationships distributions.

4.3 Relationships

The first analysis on relationships corresponds to identifying the part of speech of linking words, in order to find meaningful patterns. Figure 5 shows the relative distributions of the linking words' parts of speech, with less than 50% for the most common part of speech (verbal phrases), and at least other six relevant categories (40% between noun phrases and adverbs and adjectives), no clear patterns can be defined. This result indicates that the automatic extraction of relationships cannot rely simply on the linguistic characteristics to identify linking words.

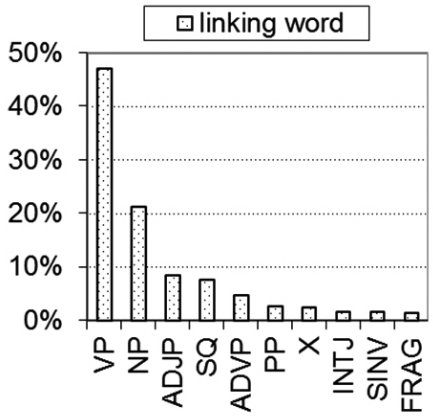


Figure 5. Part of speech frequency for linking words.

A second analysis was done trying to identify if meaningful propositions are obtained linking concepts that appear all together within paragraphs or within sentences. One example is the paragraph: "English, as a predominant and indeed 'global' language is a double edged sword. While easing communication on a global level, it also breeds elitism in countries it has been exported to." Which was represented in the concept map with the proposition "English - breeds -> elitism". An example for the sentence: "Graddol on the other hand points to the social and economic inequality that the dominance of English could lead to." Was represented as "English – lead -> the social and economic inequality".

Table 3 shows the percentage of relationships that appear within a paragraph versus those appearing within a sentence. In this case the results show a clear preference for human annotators to choose two concepts and a linking word from a single sentence. A possible explanation for this behavior could be the internal coherence of the text, indicating a bigger level of coherence within sentences than within paragraphs. This characteristic is highly relevant for CMM because it defines a pattern to identify connections for the most relevant concepts.

A final relevant analysis for relationships is comparing the sequence of a proposition within the concept map versus the essay. In the paragraph example shown before, the proposition chosen to represent the text follows the same sequence of the words in the essay, this is the source concept is followed by the linking word and then by the target concept (not necessarily one next to the other). In the sentence example on the other hand, both concepts appear before the linking word due to the grammatical structure of the sentence.

	% of Relationships
Within a sentence	92.1
Within a paragraph	7.9

Table 3. Percentage of relationships appearing within sentences or paragraphs.

In order to find out if there was a pattern indicating any preference for human annotators, the sequence of each relationship was compared to its sequence in the essay. Table 4 contains the results, showing that there's no clear pattern for choosing one type of sentences over the other. This result indicates that no conclusions can be made from the sequence of words in order to identify linking words for concepts.

	% of Relationships
Same sequence as essay	57.7
Not same sequence as essay	42.3

Table 4. Percentage of relationships following the same sequence as the essay.

5 Summary

This article explained what Concept Map Mining (CMM) is: The automatic extraction of concept maps from essays for educational purposes, and presented the analysis of a gold standard constructed for the purpose of evaluating the algorithms that will implement the task. The main goal of the analysis is to gain an understanding on the characteristics of the concept maps produced by human annotators when asked to create a summary of a piece of text. Such patterns will inform the design of the automatic algorithms that will implement CMM.

Three aspects of the concept maps and the essays were analyzed: Characteristics of the complete essay and concept map (such as the correspondence of their sizes and its correlation with the essay quality), characteristics of the concepts (such as linguistic information and frequency) and characteristics of the relationships (linguistic information, location in text and their sequence). To do this, all essays were parsed identifying grammatical roles such as noun phrases or verbal phrases, all statistics on their sizes were evaluated and each concept map was analyzed against its essay source.

The results of the analysis showed that the size of the concept maps measured in the number of concepts is correlated with the length of the essay measured in both words and sentences. However, the concept maps' connectedness has a lower correlation to their length and none of them correlates with the grades. This indicates that when humans are asked to summarize the content of an essay, they will include information based on the total information in the essay and not in its quality.

A second finding is that linguistic characteristics such as words' part of speech are useful to identify concepts with more than 90% of them sharing only three categories, but not as useful for linking words with less than 50% for the most common category. Frequency on the other hand does not help on identifying neither concepts nor linking words, both present a highly skewed distribution, meaning that only a few concepts in the concept maps appear several times in the essays, while the majority appears only once.

A final interesting finding is that most relationships can be found within a single sentence, meaning that the most relevant propositions in a concept map correspond to important sentences in an essay. This also helps explaining the skewed distribution of concepts, which could be explained by the annotators selecting a few relevant concepts and then trying to form meaningful relationships with those concepts, which were found precisely in the sentences those concepts appeared.

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To conclude, the analysis has shown that several patterns can be found in the way humans summarize text using concept maps, patterns that now have to be exploited by automatic algorithms in order to move towards the possibility of having concept maps extracted from essays.

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ANÁLISIS ESTRUCTURAL DE MAPAS CONCEPTUALES (AEMC): REVISIÓN DE LA EVIDENCIA EMPÍRICA DE 2004 AL 2010.

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Resumen. El mapa conceptual ha evolucionado de una técnica de representación gráfica de una entrevista, a una aplicación práctica de la teoría del aprendizaje de Ausubel con muy diferentes usos al que le habían dado origen. En particular, nosotros hemos desarrollado una línea de investigación basada en el Análisis Estructural de Mapas Conceptuales (AEMC) y que en inglés hemos denominado como Structural Analysis of Concept Maps, (SACMap). En este escrito realizamos un análisis de los fundamentos del AEMC, así como las aportaciones de ocho artículos: uno en inglés, tres en español, y cuatro en portugués, que se han presentado por diferentes autores en reuniones internacionales. De acuerdo con estos artículos el AEMC ha sido aplicado en diferentes grados educativos desde la secundaria hasta la educación superior permitiendo el obtener evidencia que permite tomar decisiones sobre el cómo mejorar el proceso de aprendizaje de los estudiantes. El AEMC fundamenta su análisis en la transformación de los mapas conceptuales que elaboran o completan los estudiantes en una matriz de asociación, lo cual posibilita el que se pueda realizar la suma de estas matrices y obtener una matriz grupal. Con base en esta matriz grupal se pueden genera un mapa conceptual grupal, aplicar la prueba bidimensional Olmstead-Tukey, o el Análisis Estructural Educativo. Estas son las herramientas del AEMC que producen la evidencia que permite tomar las decisiones sobre el proceso de aprendizaje en los estudiantes.

1 Introducción

El mapa conceptual fue creado hace un poco más de cuatro décadas como una solución sobre cómo representar la forma que los niños aprenden conceptos científicos, aunque fue en la década del 80 en que fue formalizado con el libro Learning how to learn por Novak y Gowin (1984). El modelo de aprendizaje en el que se basa el mapa conceptual está relacionado con el esquema pedagógico planteado por Ausubel y cuyo término más conocido es lo que se denomina como aprendizaje significativo (Ausubel, Novak y Hanesian, 1976). La influencia de este término en la educación, se percibe por el hecho de que es frecuente su inclusión en los planes y programas de estudio, ya sea como meta a lograr en los estudiantes o como justificación de la pertinencia y validez del modelo pedagógico en el que se fundamenta el currículo escolar.

En México y en otros países una de las estrategias de aprendizaje asociadas al constructivismo es el mapa conceptual, de ahí que sea frecuente encontrar en los libros de texto de libros de ciencias, mapas conceptuales como guías del conocimiento. Los resultados de investigaciones en la enseñanza de las ciencias en los últimos treinta años, confirman y apoyan la idea de que el usar mapas conceptuales favorece en los estudiantes la construcción de su conocimiento, y que los adquieran en un contexto significativo que favorece el aprendizaje de conceptos posteriores (González, 2008). Consecuencia de lo anterior es el hecho de que los mapas conceptuales son incluidos frecuentemente en libros como uno de los recursos de aprendizaje que pueden emplear los profesores (Díaz-Barriga y Hernández, 2002).

El mapa conceptual ha evolucionado de una técnica de representación gráfica de una entrevista, a una aplicación práctica de la teoría del aprendizaje de Ausubel con muy diferentes usos al que habían originado su construcción, como los muestran los más de 480 artículos presentados en las tres reuniones internacionales sobre mapas conceptuales que se han llevado a cabo en Pamplona, España (Cañas, Novak, y González, 2004), San José, Costa Rica (Cañas y Novak, 2006) y Tallin, Estonia y Helsinki, Finlandia (Cañas, Reiska, Åhlberg y Novak, 2008). De acuerdo con un análisis inicial de los dos primeras reuniones (Daley et al., 2008) serían seis las áreas sobre las cuales se han enfocado los artículos de mapas conceptuales: 1) Enseñanza y aprendizaje, 2) Desarrollo de software, 3) Valoración y puntajes, 4) Desarrollo y gestión del conocimiento, 5) Desarrollo profesional, y 6) Investigación y desarrollo de métodos de aplicación, y con diferentes líneas de investigación.

En el caso del autores de este artículo, hemos participado en el área de la enseñanza y aprendizaje, proponiendo

un procedimiento que permite transformar un mapa conceptual en una matriz de datos, y a partir de ahí realizar diferentes análisis enfocados a la toma de decisiones sobre actividades de enseñanza y aprendizaje. El nombre de esta técnica es el Análisis Estructural de Mapas Conceptuales (AEMC, González et al., 2004) o Structural Analysis of Concept Maps, (SACMap, González et al., 2008). En este artículo presentamos un análisis y revisión de los resultados que han obtenido otros autores y nosotros en la aplicación del AEMC desde el 2004.

2 Antecedentes del Análisis Estructural de Mapas Conceptuales

En la Figura 1 se muestra mediante un mapa conceptual qué es y cómo se puede utilizar el AEMC. Algunos conceptos requieren ser explicados y precisados de manera más amplia, lo cual realizaremos en esta sección.

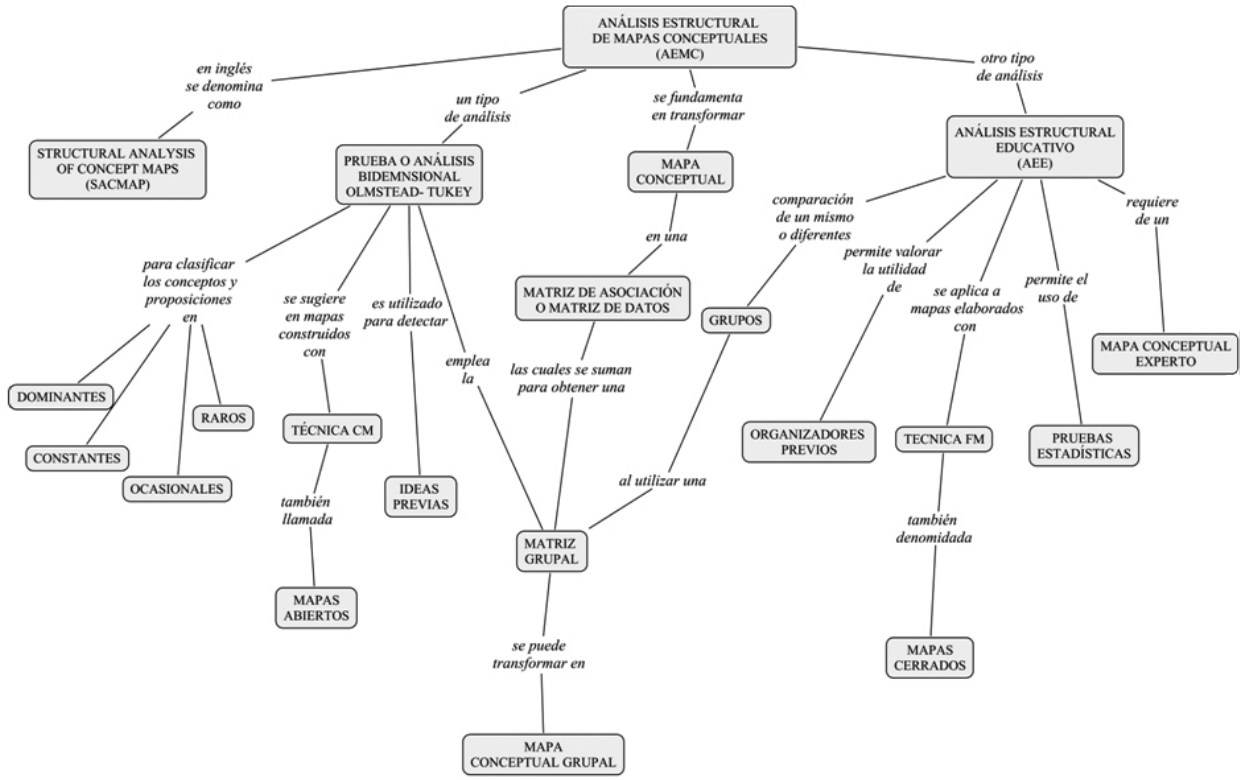


Figura 1. Mapa conceptual que explica las características principales del Análisis Estructural de Mapas Conceptuales (AEMC, González et al., 2004) o Structural Analysis of Concept Maps, (SACMap, González et al., 2008).

Ruiz-Primo y Shavelson (1996) mencionan que el uso del mapa conceptual, para explicar y evaluar como un estudiante selecciona y enlaza diferentes conceptos, requiere de considerar las piezas que lo constituyen: a) tipos de conceptos, b) tipos de líneas de conexión, c) frases o explicaciones de conexión, y d) estructura espacial o jerárquica. Ruiz-Primo et al. (2001) enfatizan que el tipo y cantidad de piezas que se le proporcionan al estudiante, influyen en la forma en que decide cómo organizar y presentar estas piezas en el mapa conceptual, precisan que hay una relación inversa entre el número piezas proporcionadas y la representación del conocimiento que pueda poseer el estudiante; a mayor número de piezas la representación de lo que sabe el estudiante es más restringida y limitada.

De manera simplificada mencionan que habría dos tipos de técnicas de elaboración de mapas conceptuales: "construct-a-map" (CM) y "fill-in-map" (FM). Un nombre que proponemos en español para los mapas CM es el de mapas abiertos, en el sentido de que el estudiante puede agregar piezas de su estructura cognoscitiva al mapa conceptual, y en el caso de los mapas FM, mapas cerrados, ya que el estudiante no puede agregar piezas de su estructura cognoscitiva al mapa conceptual, solo acomodarlas. Al ser una revisión de lo que se ha realizado por medio del

AEMC, conservaremos en este artículo el nombre de técnica FM y CM, pero si consideramos que en futuros trabajos, en el idioma español, es conveniente emplear los nombres de mapas abiertos y cerrados de acuerdo a la técnica que se empleó en su elaboración. La técnica CM consiste en que partir de las piezas que se le proporcionas al estudiante, este debe elaborar su mapa conceptual. La técnica FM consiste en proporcionarle al estudiante un mapa conceptual al que se le han quitado algunos de sus elementos y el papel del estudiante consiste en completar esas piezas faltantes. El mapa conceptual que se le suministra al estudiante es un esqueleto o plantilla de un mapa elaborado por un experto del tema, de ahí que se le denomine como mapa experto. Hernández (2005) añade que al proporcionarle una lista con los elementos, se evitan problemas de equivalencia semántica entre los elementos que propuestos por un estudiante y los sugeridos en el mapa experto. Sin embargo, esto permite la posibilidad de que el estudiante intente adivinar el sitio en que debe ir la pieza en el mapa experto, en lugar de analizar en dónde debe colocarse. Otro aspecto que fue corroborado con evidencia empírica, es que el empleo de las técnicas FM y CM producen mapas que no son equivalentes en su interpretación, por lo cual son enfoques diferentes de representaciones de lo que aprendió el estudiante (Ruiz-Primo et al., 2001; Ruiz-Primo, 2004; Yin et al., 2005).

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Una vez que ha terminado el estudiante de completar o elaborar el mapa conceptual, la siguiente etapa es interpretar el mapa conceptual. De manera práctica, una de las limitantes es el tiempo que se invierte en este proceso. En nuestro ámbito escolar en México, es frecuente encontrar que un grupo escolar tenga más de 40 alumnos, por lo cual el procesar la información generada por tantos mapas es complejo. Lo que nos interesó es cómo integrar los mapas conceptuales que producen cada uno de los estudiantes en un solo mapa conceptual grupal. Este mapa grupal permitiría el tomar decisiones con respecto a un proceso de aprendizaje.

El AEMC está sustentado en dos instrumentos: el Análisis Estructural Educativo (AEE) propuesto por Solano (1989) y la Prueba o Análisis Bidimensional Olmstead-Tukey (Sokal. & Rohlf, 1985). Como detallamos en González et al. (2006) estos dos instrumentos comparten el hecho de que los datos a procesar, requieren de ser transformados en arreglos de renglones y columnas que denominaremos como matriz de asociación o matriz de datos. En el caso del mapa conceptual, el procedimiento consiste en transformar las proposiciones del mapa conceptual en una matriz de datos. De esta forma al sumar las matrices de cada uno de los mapas se obtiene una matriz grupal. A partir de la matriz grupal es que se puede optar por realizar diferentes análisis:

a) Análisis Bidimensional Olmstead-Tukey; si los mapas conceptuales son elaborados con la técnica CM es posible identificar y clasificar de forma gráfica cuales son los conceptos dominantes, constantes, ocasionales y raros, en un grupo de mapas. Si se utiliza la técnica FM, permite detectar si hay cambios en cómo el grupo apreciaba los conceptos (con base en las categorías de dominantes, constantes, ocasionales y raros) después de la aplicación de un método o estrategia de aprendizaje.

b) AEE; permite generar mapas conceptuales de grupo que describen con indicadores cuantitativos, si hay cambios en las proposiciones propuestas por el mapa experto. De forma adicional permite detectar proposiciones válidas de los estudiantes que pueden estar ubicadas en un lugar jerárquico distinto del mapa experto.

Es de esta manera que propusimos el AEMC como un mecanismo de diagnóstico (González et al., 2004) y evaluación de métodos o estrategias de aprendizaje (González et al., 2006, González et al., 2008). Con base en los resultados, que comentaremos más adelante, el AEMC puede ser aplicado como herramienta de diagnóstico tanto si los mapas conceptuales son elaborados mediante la técnica CM como la FM, pero si se desea utilizar como herramienta de validación de métodos o estrategias de aprendizaje, los mapas conceptuales tienen que ser elaborados por la técnica FM.

3 Cómo se ha utilizado el AEMC

En las Tablas 1 y 2 se muestra un cuadro analítico de las investigaciones en que han aplicado el AEMC; los datos fueron divididos en dos tablas para su facilitar su lectura.

Autores	Temas abordados	Herramientas de análisis
[1] González *et al.*(2004)	Ideas previas en Biología, secuencia de contenidos en programas de estudio, comparación de grupos de diferentes sistemas educativos.	• Matriz de asociación grupal • Olmstead-Tukey • Prueba de χ^2 (chi cuadrada)
[2] González *et al.*(2006)	Células madre, evaluación de la estrategia CTS injerto o casos simulados, evaluación de aprendizaje de contenidos científicos, comparación en un mismo grupo.	• Matriz de asociación grupal • Olmstead-Tukey • Prueba de χ^2 (chi cuadrada) • AEE • Mapa conceptual grupal
[3] Gonçalves y Maximiano (2008)	Equilibrio químico, comparación de grupos en diferentes turnos.	• Matriz de asociación grupal • Olmstead-Tukey • Mapa conceptual grupal.
[4] Martins y Maximiano (2008a)	Ideas previas sobre transformación química, comparación de un mismo grupo.	• Matriz de asociación grupal
[5] Martins y Maximiano (2008b)	Ideas previas de cómo se lleva a cabo la ciencia.	• Matriz de asociación grupal • Mapa conceptual grupal.
[6] González *et al.*(2008)	Teoría de la evolución, evaluación de la estrategia WebQuest-Injerto (TIC-CTS), comparación de grupo testigo y experimental.	• Matriz de asociación grupal • Olmstead-Tukey • Prueba de χ^2 (chi cuadrada) • AEE Mapa conceptual grupal
[7] Gonçalves y Maximiano (2009)	Equilibrio químico, Termodinámica, comparación de grupos en diferentes turnos.	• Matriz de asociación grupal • Olmstead-Tukey • Mapa conceptual grupal. • Prueba exacta de Fisher
[8] Soares *et al.* (2010)	Ideas previas sobre suelo, comparación de grupos de diferentes escuelas	• Matriz de asociación grupal • Olmstead-Tukey

Tabla 1. Comparación de los artículos que han utilizado el Análisis Estructural de Mapas Conceptuales (AEMC, González et al., 2004) o Structural Analysis of Concept Maps, (SACMap, González et al., 2008); en la primera columna se cita a los autores de la publicación, y en la segunda se mencionan los temas que se abordaron en el artículo, y en la tercera el tipo de análisis efectuados.

En la Tabla 1 se puede apreciar que los temas abordados se ubican en las disciplinas de la Biología y la Química. La matriz de asociación es la base de los análisis del AEMC, ya que de ahí se pueden abordar un análisis comparativo de las proporciones o porcentajes encontrados (Martins y Maximiano, 2008a) o el análisis bidimensional Olmstead-Tukey (González et al., 2004, Soares et al., 2010).

Una profundización en el AEMC es la elaboración de los mapas grupales con y sin pruebas estadísticas (Martins y Maximiano, 2008b; Gonçalves y Maximiano, 2009) y si es el caso, la inclusión del AEE (González et al., 2006; González et al., 2008). El carácter diagnóstico de ideas previas que permite este análisis facilita el plantear diferentes hipótesis a verificar, como se describen en los diferentes artículos. Por otra parte la generación de mapas grupales, es frecuente en los trabajos, siendo la principal aportación del AECM al condensar los mapas conceptuales individuales en un mapa conceptual grupal.

En la Tabla 2 se aprecia que el AECM ha sido aplicado en diferentes niveles educativos. Por otra parte el análisis Olmstead-Tukey se ha mostrado sensible al tipo de técnica que se empleó para elaborar el mapa conceptual; al profundizar en el uso del mapa experto, los resultados indicaron que las modificaciones al mapa experto requieren de adaptaciones para evitar sesgos en la interpretación de la información (González et al., 2008; Gonçalves y Maximiano, 2009). Otro factor no tan evidente que puede modificar los resultados es el tipo de pieza que se le suministra al estudiante, ya sea en forma de pregunta o en una lista de conceptos. Una hipótesis a verificar sería corroborar si el análisis Olmstead-Tukey es sensible a esta situación. Al respecto, una dificultad que ya que habíamos indicado

Autores	Nivel educativo.	Origen de la matriz grupal.	Aportación al AEMC.
[1] González *et al.*, (2004)	Bachillerato; quinto año	Mapas elaborados por la técnica CM de una lista de 20 conceptos.	• Análisis Bidimensional Olmstead-Tukey
[2] González *et al.*, (2006)	Bachillerato; sexto año	Mapas elaborados por la técnica FM de lista de 16 conceptos.	• AEE • Inclusión de categoría de concepto terminal en el mapa experto.
[3] Gonçalves y Maximiano (2008)	Superior, sexto semestre licenciatura de Química	Mapas elaborados por la técnica CM de una lista de 36 conceptos.	• Validación como estrategia para la identificación de conceptos principales de una lista grande (36 palabras)
[4] Martins y Maximiano (2008a)	Secundaria	A partir de textos elaborados por los alumnos de una lista de 16 conceptos.	• Elaboración de matrices grupales a partir de textos escritos por los alumnos.
[5] Martins y Maximiano (2008b)	Superior, tercer semestre de la licenciatura de Química.	A partir de textos elaborados por la alumnos respondiendo a una pregunta.	• Elaboración de mapas grupales a partir de textos escritos por los alumnos.
[6] González *et al.*, (2008)	Bachillerato; quinto año.	Mapas elaborados por la técnica CM a partir de una pregunta y por la técnica FM de una lista de 29 conceptos.	• Sugerencias para la modificación del mapa experto con las categorías terminales.
[7] Gonçalves y Maximiano (2009)	Superior, sexto semestre licenciatura de Química.	Mapas elaborados por la técnica CM a partir de una lista de 36 conceptos.	• Indicador generado con el uso de las matrices grupales para evaluar las diferencias entre los grupos a comparar
[8] Soares *et al.*, (2010)	Secundaria; octavo grado de educación básica.	Mapas elaborados por la técnica CM a partir de una pregunta.	• Elaboración de matriz de asociación a partir de la identificación de las proposiciones correctas en los mapas de los estudiantes.

Tabla 2. Comparación de los artículos que han utilizado el Análisis Estructural de Mapas Conceptuales (AEMC, González et al., 2004) o Structural Analysis of Concept Maps, (SACMap, González et al., 2008); en la primera columna se cita a los autores de la publicación, y en la segunda se mencionan el grado educativo al que pertenecen los estudiantes de la investigación, en la tercera a partir de que datos se construyó la matriz de asociación, y en la cuarta la aportación al AEMC.

(González et al., 2004) y referida también por Gonçalves y Maximiano (2009), es que el análisis no detecta de forma precisa las relaciones que se establecen, sino únicamente como los conceptos son percibidos de forma grupal. De ahí que la relevancia de la aportación de Soares et al. (2010) en el sentido de identificar las proposiciones correctas en un mapa conceptual elaborado a partir de una pregunta, antes de trasladarlas a la matriz grupal y emplear el análisis Olmstead-Tukey.

En lo referente al análisis AEE se requiere que los mapas conceptuales correspondan a la técnica de elaboración FM, ya que los mapas elaborados por la técnica CM producen muchas proposiciones válidas de manera individual, pero escasas en el plano grupal. Por otra parte, el AEE es útil en los casos que se desea validar alguna estrategia de enseñanza, ya que permite comparar las proposiciones de los mapas conceptuales de forma más precisa que el análisis Olmstead-Tukey, además de establecer la posibilidad de aplicar pruebas estadísticas. Sin embargo su desventaja radica en se requieren que los mapas estén elaborados mediante la técnica FM.

4 Cuáles podrían ser las líneas de investigación a seguir del AEMC

En el caso de los mapas CM un elemento importante es el identificar cuando un mapa tiene deficiencias en su elaboración por la impericia del estudiante al manejar la técnica; en González et. al (2008) aplicamos una clasificación taxonómica (Cañas et al., 2006) que consideramos útil para este propósito. En esa investigación utilizamos que los mapas tendrían que tener un nivel de 2 para ser evaluados. Una línea de investigación a partir del trabajo de puede

enfocarse a la validez de ese supuesto, para la adecuada aplicación del análisis Olmstead-Tukey.

En ese trabajo (González et. al, 2008), también mencionamos el uso de algunas de las bases de una instrumento llamado Modelo de Análisis Proposicional (MAP, retomado de Campos et al., 1999 y Campos, 2005) el cual está diseñado para identificar las ideas principales de una organización conceptual de acuerdo a su contenido lógico y conceptual, mediante el análisis de proposiciones de un texto escrito, como realizaron Martins y Maximiano (2008 y 2009). La línea de investigación consistiría en utilizar el MAP para interpretar los mapas conceptuales, en lugar del discurso escrito, y convertirlo en una matriz de datos y aplicar el AEMC, como realizó Soares et al. (2010) por medio de preguntas, en lugar de una lista de conceptos. El uso de otros instrumentos adicionales, sugiere la necesidad de construir un marco teórico de la técnica del AEMC con relación a otros métodos de análisis y evaluación de mapas conceptuales, para así identificar y establecer la contribución a la evaluación con mapas conceptuales.

Una característica de los resultados de las investigaciones que aplicaron el AEMC, es la toma decisiones con respecto al curso del proceso de enseñanza y aprendizaje. Por ejemplo, en el caso de equilibrio químico permite identificar conceptos clave manejados por el grupo de alumnos, y que a través de la interpretación que realiza el docente, puede catalogar estos conceptos clave como oportunidades para construir futuros conceptos, y en otra vertiente, como aquellos conceptos que requieren una modificación o reestructuración por parte del estudiante.

Una posible línea de investigación consistiría en determinar si estas decisiones que toma el docente están contribuyendo al logro de aprendizajes significativos asociados a contenidos específicos de disciplinas científicas como puede ser la evolución biológica, por mencionar uno. Esto significaría una línea de investigación diferente, ya que requiere del empleo de otras técnicas de investigación, como la entrevista o la encuesta, para conocer cómo la decisión tomada a partir de los resultados del AEMC contribuyó a una restructuración adecuada de sus ideas previas, y si fuese el caso de sus métodos y estrategias de aprendizaje.

A manera de conclusión podemos mencionar que el AEMC es una herramienta que en los últimos seis años se ha aplicado en diferentes situaciones de aprendizaje y grados educativos. En las investigaciones efectuadas se ha obtenido evidencia para tomar decisiones que intentan favorecer el aprendizaje de los estudiantes al valorar estrategias de aprendizaje, recuperar ideas previas, y en su caso orientar mediante el uso de organizadores previos.

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APRENDIZAJE SIGNIFICATIVO SOBRE EL TEMA TIERRA Y UNIVERSO: EL USO DE MAPAS CONCEPTUALES COMO RECURSO FACILITADOR

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Resumen. En el presente artículo se relatan los resultados parciales de una investigación de delineación casi experimental con alumnos del 6º año de enseñanza Fundamental que frecuentan una escuela pública en tiempo integral en Guarulhos, São Paulo, Brasil. Esta investigación tuvo como objetivo comprender como los Mapas Conceptuales contribuyen para el proceso de adquisición de los conceptos de Tierra y Universo actuando como recurso facilitador del aprendizaje significativo. El análisis de los resultados nos permite afirmar que el grupo de testeo, es decir, el que ha realizado mapas conceptuales, manifestó en relación al grupo control una tenue capacidad de organizar y representar los conocimientos adquiridos, por medio de un lenguaje descriptivo y comunicativo de los conceptos científicos aprehendidos durante las clases impartidas. El segundo paso a dar, en el sentido de complementar los resultados de esa investigación es un análisis cualitativo de los mapas conceptuales elaborados por los alumnos del grupo de testeo.

1 Introducción

Según las recomendaciones de la propuesta curricular de enseñanza de Ciencias Naturales (São Paulo, 2008a), la implicación pedagógica del tema Tierra y Universo, como contenido inicial en el 6º año tiene por objetivo ampliar los conocimientos adquiridos por el alumno en el final del 5º año, tras estudiar el tema Planeta Tierra. Por dichas razones, el profesor debe organizar la enseñanza de forma que permita al alumno avanzar conceptualmente y consecuentemente aumentar su visión de mundo, utilizando para eso la observación del Cielo como punto de partida del proceso de construcción del conocimiento sobre el Universo Cosmológico, en donde el planeta Tierra está ubicado en una pequeña fracción que es el Sistema Solar. Y aun se recomienda al profesor utilizar varias estrategias didácticas estimuladoras del ejercicio de interacción entre los diversos conceptos científicos ya construidos y nuevos conceptos propuestos para la materia de enseñanza que permitan al alumno avanzar en el conocimiento sobre el tema.

A pesar de que las orientaciones de la propuesta contribuyen con la enseñanza en clase, investigaciones han demostrado que el profesor aun enfrenta muchas dificultades para crear condiciones para que el alumno avance en el conocimiento sobre dicho tema, lo que normalmente poco contribuye para el aprendizaje significativo de ese alumno. El no aprendizaje se revela en la fragilidad conceptual que el alumno presenta en los años subsiguientes. Esa fragilidad conceptual sobre temas de Astronomía fue apuntada en investigaciones de Baxter (1989); Trumper (2001); Kriner (2004).

Otro indicador relevante es el Sistema de Evaluación de Rendimiento Escolar del Estado de São Paulo que evidenció el bajo índice de aprovechamiento del alumno, de esa escuela, en Ciencias Naturales, es decir, el alumno presenta dominio insuficiente de los contenidos deseables para el año en que se encuentra, en función de eso, se clasifica en el nivel abajo del básico (São Paulo, 2008b). Por su vez, se espera que dichos resultados sirvan como referencia al desarrollo de acciones para la superación de problemas de aprendizaje y en la proposición de situaciones de enseñanza que busquen el aprendizaje significativo, no solamente en temas de Astronomía, sino como en otros temas de Ciencias Naturales.

En este contexto, la adquisición de conceptos científicos en Ciencias Naturales, con vistas al aprendizaje significativo, pasó a constituir un asunto de gran interés para esta investigación. Presupone la necesidad de seleccionar y articular los conceptos científicos, durante la enseñanza, de forma a permitir la interpretación cuidadosa de los fenómenos naturales según lo que se acepta en la comunidad científica y de esa forma, favorecer el avance de los conocimientos

previos adquiridos por el alumno a lo largo de su trayectoria escolar. Eso representa la organización de una propuesta de enseñanza que contemple la relación entre los objetivos educacionales, los contenidos científicos y actividades potencialmente significativas. Visto que, la comprensión de los conceptos científicos sugiere un proceso continuo de interacción entre la metodología de enseñanza, el contenido a ser enseñado y la relación profesor alumno.

De esa forma, se utilizó como un ambiente de investigación la clase, en donde aprender significativamente involucró la comprensión de conceptos relevantes de la materia a enseñar, transformados a partir del sentimiento, del pensamiento y de la acción (Novak, 2000) y para mantenerla se estableció la interdependencia entre los objetivos trazados, el conocimiento conceptual del alumno, el contexto, el recurso didáctico y la evaluación . Y para garantizar el proceso de enseñanza y aprendizaje, el contenido se estructuró con base en los principios de la "diferenciación progresiva" y de la "reconciliación integrativa" (Ausubel 2002; Moreira, 2008), con especial destaque al uso del mapa conceptual como recurso facilitador del aprendizaje significativo.

Estudios de Novak (2000) y Moreira (2008), y varios estudios más sobre mapas conceptuales, demuestran que el mapa conceptual permite la visualización de las relaciones entre conceptos, existentes en la estructura cognitiva de los alumnos y, como tal, se puede utilizar para acompañar la evolución y externalización de los conceptos de la materia a enseñar durante el proceso de aprendizaje. Proveniente de esos estudios, la pregunta que se intentó contestar con la investigación fue: ¿El uso del mapa conceptual como recurso didáctico facilita el aprendizaje significativo en Ciencias Naturales en la enseñanza Fundamental? Se puso como hipótesis que tal recurso se puede utilizar para acompañar la evolución y la externalización de los conceptos de Tierra y Universo del alumno de 6º año (actualmente 7º año). Por dichas razones, la presente investigación objetivó comprender como el Mapa Conceptual contribuye para el proceso de adquisición de conocimiento de los conceptos de Tierra y Universo, actuando como recurso facilitador del aprendizaje, a la luz de la Teoría del aprendizaje significativo de David Ausubel.

2 Referencial Teórico

Al proponer la teoría de asimilación cognitiva, Ausubel identificó que el factor más importante que influye en el aprendizaje es lo que el alumno ya sabe. Por dichas razones, el profesor debe verificar los conocimientos previos de su alumno para que pueda enseñarlo a partir de estos conocimientos (Ausubel, 2002). En ese sentido, la práctica pedagógica no debe negar las representaciones conceptuales consideradas prominentes en la estructura cognitiva del alumno, que sirvieron de base a los nuevos conceptos e ideas. Eso quiere decir que el profesor debe determinar las necesarias conexiones entre lo que se enseña y lo que el alumno ya conoce (Novak, 2000).

Para complementar las ideas citadas, reportamos a las afirmaciones de Moreira (2008) cuando aclara que el aprendizaje significativo es aquél en que "el significado del nuevo conocimiento se adquiere, atribuye, construye, por medio de la interacción con algún conocimiento previo, específicamente relevante, existente en la estructura cognitiva del aprendiz" (p. 15-16). El autor argumenta también que la palabra clave es la interacción, que favorece a la modificación tanto del conocimiento previo como del nuevo conocimiento, es decir, "el nuevo pasa a tener significados para el individuo y el previo adquiere nuevos significados, queda más diferenciado, más elaborado" (p. 16). Resalta, aun, que el nuevo conocimiento no interacciona con cualquier conocimiento previo y sí con un conocimiento relevante que favorezca la atribución de significados de forma no arbitraria.

Por ejemplo, en Ciencias Naturales, en relación al concepto de Tierra y Universo, si el profesor obtiene el conocimiento previo de la visión espacial que el alumno presenta del cielo y del Sistema Solar, podrá establecer actividades que amplíen la visión de mundo del alumno, favoreciendo la interacción entre lo que es observado en el cielo y el universo cosmológico en donde están presentes los principales elementos del Sistema Solar.

Es necesario que se insista en el hecho de que el aprendizaje significativo es contextual, es decir, considerado correcto dentro del contexto de la materia a enseñar. Al preguntar a los alumnos sobre lo que existe en el cielo, el profesor se encuentra con diversas respuestas tales como: pájaros, avión, ángeles, Dios, contaminación, las cometas, globos (Leite y Hosoume 2008). Estas respuestas no se pueden considerar incorrectas, sin embargo en el contexto del tema 'Tierra y Universo' lo que se espera como conocimiento previo son respuestas como: estrellas, Sol, Luna, planetas, constelaciones, nubes. Conceptos relevantes para la materia a enseñar, que pueden servir de base a nuevos conocimientos sobre el Universo Cosmológico, cuando se trata del currículo en Ciencias Naturales.

Para promover el aprendizaje significativo, Novak (2000) y Moreira (2006) recomiendan al profesor el uso de mapa conceptual como recurso (Figura 3), con la finalidad de identificar significados (subsunsores) en la estructura cognitiva del educando, necesarios al aprendizaje. El mapa usado como recurso facilitador del aprendizaje, cuando elaborado por el alumno, presenta también, componentes idiosincráticos (personales) que se deben llevar en consideración, por el profesor, al analizarlo. Eso significa decir que todo mapa conceptual puede ser utilizado para dialogar con el estudiante sobre el conocimiento externalizado en el mapa. Lo importante es la presentación y la discusión alrededor del entendimiento externalizado en clase, durante su elaboración.

Naturalmente, el profesor, en su actuación, tiene la intención de hacer con que el alumno adquiera ciertos significados que son aceptados en el contexto de la materia a enseñar, los cuales por su vez, son compartidos por el alumno. El uso del mapa es también útil para que el profesor alcance este objetivo y explique como lo está alcanzando. De esta forma, se entiende que el mapa conceptual es un instrumento cuyo uso y construcción se debe evaluar, sobretodo, cualitativamente, a fin de obtener evidencias de aprendizaje significativo (Moreira, 2006).

El meollo del método está en que estudiantes y profesores comparten y alcanzan nuevos significados, los cuales deben resultar en nuevos conceptos clave, favoreciendo el aprendizaje significativo. Así, el profesor inicia un evento educativo (clase) utilizando material potencialmente significativo, que puede ser el mapa conceptual, para enseñar a los alumnos de forma que puedan captar el significado de los conceptos de su materia a enseñarse. En ese momento, el profesor auxilia el alumno a volverse consciente de lo que ya sabe y a observar la importancia de utilizar sus conocimientos y experiencias previas, es decir, ayuda a conectar el conocimiento previo al nuevo conocimiento (Gowin y Alvarez, 2005). Por lo tanto, una enseñanza auxiliada por mapa conceptual aumenta el poder de pensamiento y conocimiento del alumno sobre el contenido que el profesor desea enseñar.

Al elegir el mapa conceptual como recurso potencialmente significativo, debemos también, considerar que el movimiento de aprender y construir conocimiento sucede en una secuencia no linear. Siendo así, el profesor debe organizar la enseñanza de forma intencional, dentro de los principios de "diferenciación progresiva" y "reconciliación integrativa", con la finalidad de facilitar el aprendizaje significativo. Según Moreira (2008 p. 37), "la diferenciación progresiva consiste en presentar en el inicio de la instrucción, las ideas, los conceptos y las proposiciones más generales e inclusivas del contenido y, progresivamente, diferenciarlos en términos de detalles y especificidad. La reconciliación integrativa es el principio programático según el cual la enseñanza debe también explorar relaciones entre ideas, apuntar similitudes y diferencias, reconciliar discrepancias reales o aparentes."

Para finalizar, entendemos que la enseñanza de Ciencias Naturales debe ser reestructurada cognitivamente, observando todas las posibilidades, considerando que el conocimiento previo del alumno es base para la construcción del conocimiento científico. Si es bien estructurado en el compás de la investigación, permite al profesor generar nuevos desafíos, condición indispensable para establecer relaciones significativas, en clase, que favorezcan el desarrollo de jóvenes ciudadanos, volviéndolos más reflexivos y creativos.

3 Metodología

La investigación buscó soporte metodológico en los abordajes cuantitativo y cualitativo propuestos por Bericat (1998), inicialmente, se trazó una delineación casi experimental (figura4), debido a la ausencia de la posibilidad de un total control sobre todas las variables o situaciones en las cuales no hay posibilidad de randomizar los grupos de estudio (Moreira y Rosa, 2007). Para ejemplificar, presentamos algunas situaciones que interfirieron en el control de las variables: la primera se refiere a la organización de las clases, siendo de responsabilidad de la gestión escolar y no del profesor-investigador. La segunda está en la regularidad de la frecuencia del alumno a la clase. Y la tercera corresponde a la ausencia de la vivencia de los temas propuestos como contenido curricular en los años anteriores, por parte del alumno.

La población de ese estudio estuvo compuesta por los alumnos de los 6ºs, 7ºs y 8ºs de enseñanza Fundamental de la Escuela Estadual de Tiempo Integral (ETI) Prof. José Scaramelli, ubicada en el municipio de Guarulhos, São Paulo, Brasil. En ese artículo, presentamos los resultados de la investigación con los alumnos de los 6ºs años, cuayo muestra consistió en 47 alumnos, en la franja etaria entre 11 y 13 años, siendo 21 alumnos del grupo A y 26 alumnos del grupo B. La recolección de datos ocurrió a lo largo del. semestre de 2008, con tres clases semanales, lo que completó alrededor de 60 clases por

semestre, con duración de 50 minutos cada una. La definición del grupo control y grupo testeo fue resultado de un sorteo.

La recolección de datos se inició por medio de una "evaluación diagnóstica (AD)" sobre el tema propuesto, como sugiere Meneses (2001) con el propósito de levantar los conocimientos previos de los alumnos, en ambos grupos. Esta evaluación estuvo compuesta por 20 cuestiones que involucraban respuestas interpretativas, razonadas e ilustrativas. Tras esta evaluación estructuramos el planeamiento de enseñanza, que constó de varias estrategias tales como: clase expositiva dialogada y utilización de libros didácticos; lectura de artículos científicos con relatos orales y escritos; elaboración de dibujos y esquemas; resolución de ejercicios y guiones de estudio; lectura, elaboración y análisis de gráficos y tablas. Además de esas estrategias, el "grupo testeo" confeccionó mapas conceptuales.

Para el desarrollo de las clases, fueron seleccionados los contenidos relativos al tema 'Tierra y Universo' representado por los Elementos Astronómicos visibles en el cielo: Sol, Luna, estrellas, planetas y galaxias; Ubicación de las principales estrellas en el cielo; las constelaciones; Movimiento de los objetos en el cielo en relación a la Tierra en la visión geocéntrica; Estructuración del Sistema Solar: el Sol y los planetas en el espacio; Características físicas de los planetas en comparación a la Tierra: tamaños, distancias, temperatura, tiempo de rotación y traslación; Estimativas de las dimensiones del Sistema Solar y Representación en escala del Sistema Solar.

Tras la intervención, se aplicó la "evaluación del aprendizaje (AP)" que constó de las mismas cuestiones propuestas en la "evaluación diagnóstica (AD)", con el intuito de analizar y comparar la evolución individual del alumno, la evolución general de cada grupo, además de comparar el grupo de testeo con el grupo control. El instrumento de recolección de datos (evaluaciones) fue sometido a la validación por un especialista del Núcleo de Astrofísica Teórica de la ciudad de São Paulo. Además, para medir la fiabilidad del instrumento de evaluación, se calculó el coeficiente alfa de Cronbach (Cronbach, apud Moreira y Veit, 2007), como medida de consistencia interna de las cuestiones. La literatura indica que, cuando se evalúan grupos, son aceptables valores de alfa próximos de 0,7. El coeficiente alfa calculado a partir de las respuestas del grupo B, fue de 0,748. Por lo tanto, esos resultados permitieron aplicar el mismo instrumento (evaluación) también en el grupo de 6º año A, siendo las respuestas corregidas con base en el mismo parámetro de corrección aplicado al grupo de 6º año B. Durante la fase de corrección de las evaluaciones utilizamos una escala con tres intervalos para cada ítem evaluado (0,0; 0,25; y 0,5), con base en los errores y aciertos sobre el contenido de las cuestiones que estuviesen de acuerdo con lo establecido por la comunidad científica del área. Para el análisis de los datos, calculamos el promedio de los resultados de las evaluaciones.

Posteriormente, el contenido de las respuestas de los 2 grupos (A y B) se categorizó (Bardin, 2004), buscando facilitar el análisis de los conocimientos previos sobre el concepto de Tierra y Universo, por parte de cada alumno evaluado. En la interpretación de los datos se hizo necesario efectuar un recorte del contenido de las respuestas en elementos y ordenarlos dentro de las categorías, cuya finalidad consistió básicamente en agrupar tales elementos en función de su significación (Bardin, 2004). Los elementos seleccionados constituyeron unidades de análisis o clasificación, visto que se pusieron en algunas categorías más de una palabra o concepto. Las categorías así formadas representan el significado que el grupo de alumnos atribuyó a los conceptos.

Como indicadores de aprendizaje se utilizaron las siguientes competencias: caracterización de objetos astronómicos, diferenciando la variedad de elementos del Cielo; Identificación del movimiento aparente del Sol; Caracterización y diferenciación de los astros pertenecientes al Sistema Solar; Reconocimiento de las distancias entre Planetas en relación al Sol; Ubicación y formación de la luz del Sol; Identificación del movimiento y ubicación de la Luna; Identificación de las fases de la Luna; Significación de Constelaciones.

4 Resultados y discusión

La discusión sobre los conocimientos científicos en Ciencias Naturales, en lo que se refiere al tema Tierra y Universo, poco se hace presente en los años anteriores de ese grupo de alumnos. Los resultados, presentados a continuación evidenciaron que los conocimientos previos prominentes en la estructura cognitiva de la mayoría, son insuficientes para basar los conceptos científicos necesarios al desarrollo de las competencias elegidas para la materia a enseñar, demostrando, al profesor, la necesidad de organizar la enseñanza en el sentido de determinar las necesarias conexiones entre lo que es enseñado y lo que el alumno ya conoce (Novak, 2000). Una estrategia de aproximación del conocimiento científico a ser aprehendido es un elemento clave, para la adquisición de este conocimiento, que los habilita tanto para

posicionarse delante las modificaciones del mundo en que viven como para comprender los fenómenos observables en la naturaleza y en el Universo (São Paulo, 2008b).

Analizando los resultados bajo la perspectiva de los indicadores de la estadística descriptiva simple, verificamos que el promedio del grupo de testeo tuvo una mejora entre la evaluación inicial y la final (de 4,27 a 5,30). Esta mejora, aunque no sea altamente expresiva, es indicativa de que el conjunto de los alumnos evolucionó positivamente en el conocimiento. El Grupo Control también presenta un indicativo de evolución, con el promedio pasando de 3,58 de la evaluación inicial a 4,08 en la evaluación final. Evidentemente, la evolución del Grupo Control no fue tan expresiva, aunque también positiva, a pesar de que las notas de ese grupo hayan sido inferiores a las del otro grupo. Ciertamente, las fragilidades de los conocimientos previos del grupo control tuvieron mayor influencia en el desempeño de ese grupo. Eso muestra la importancia de verificar los conocimientos previos del alumno para que el aprendizaje sea significativo, como determina Ausubel al proponer la Teoría de Asimilación Cognitiva (Ausubel, 2002). Los conocimientos previos sirvieron de parámetros para la intervención de lo que se deseaba enseñar y a partir de eso, determinar el nivel de evolución del conocimiento del alumno, es decir, aprendizaje con significado sobre el tema.

El aspecto más interesante que analizamos en esta perspectiva cuantitativa de los resultados, fue el comportamiento de la medida de dispersión 'desvío patrón' de los grupos. Percibimos que el grupo de testeo evolucionó para una reducción en la dispersión de los resultados. En otras palabras, los alumnos de grupo de testeo presentaron la tendencia de evolución para un mismo sentido, es decir, positivamente. Ya el Grupo Control presentó comportamiento inverso, cual sea: hubo una ampliación en la dispersión de los resultados, pasando de 1,51 a 1,81. Tomada esta información sobre la dispersión de los resultados, en conjunto con la evolución positiva del promedio en relación a los conceptos científicos sobre el tema Tierra y Universo, se puede inferir que la evolución del desempeño del alumno con evaluación inferior a la del promedio de su grupo fue peor que la evolución del desempeño del alumno con evaluación superior, lo que se refleja en el aumento del desvío patrón de los resultados de la evaluación cuantitativa del Grupo Control. En ese sentido, podemos afirmar que el grupo de testeo, es decir, el que realizó mapas conceptuales, demostró una capacidad de organizar y representar conocimientos adquiridos, por medio de un lenguaje descriptivo y comunicativo de los conceptos aprehendidos durante las clases impartidas según observa Moreira (Moreira, 2006), cuando plantea sobre la importancia pedagógica del mapa conceptual.

Cuanto al contenido de las respuestas, analizado con base en las categorías de significados, atribuidos por el alumno al concepto, presentamos los resultados referentes a los elementos astronómicos visibles en el Cielo, el movimiento aparente del Sol y la caracterización y diferenciación de los astros pertenecientes al sistema solar. Tomando como ejemplo la "categoría elementos astronómicos" los resultados nos muestran que en el grupo testeo hubo un avance en la citación de conceptos de elementos astronómicos y una reducción de citaciones de elementos cultural-religiosos tras la intervención, evidenciando un posible diferencial entre los recursos de aprendizaje utilizados, visto que, ese grupo aprendió y elaboró mapas conceptuales. Cuando se tiene una enseñanza ayudada por mapa conceptual, según Gowin y Alvarez (2005), se aumenta el poder de pensamiento y conocimiento del alumno sobre el contenido que deseamos enseñarle.

Categorías/ Elementos	Grupo Testeo				Grupo Control			
	Diagnosis		Aprendizaje		Diagnosis		Aprendizaje	
	Respuestas	%	Respuestas	%	Respuestas	%	Respuestas	%
Astronómicos	Luna, Sol, Estrellas, Planetas, Astros, Constelación, Galaxia, eclipse.	42	Sol, Luna, planetas, estrellas, satélites, astros, cometas asteroides, eclipse, **meteoros, sistema solar, universo.**	52	Planeta, estrella, sistema solar, Luna, Sol, meteoritos, eclipse, meteoros, cometas, intergaláctica.	51	Planeta, estrella, Luna, Sol, meteoritos, eclipse, meteoros, cometas, **asteroides**.	50
Físicos/ Químicos	Arco iris, Atmósfera, oxígeno, nubes, capa de ozono, evaporación, lluvia, aire, agua, trueno	38	Nubes, atmósfera, cielo azul.	34	Nubes, arco iris, lluvia, viento, agua.	47	Nubes, arco iris, lluvia, aire.	42
Culturales/ Religiosos	Ángeles, Dios, personas que ya murieron	08	Dios	03	Dios.	02	---	---
Biológicos	Pájaros, gavilán	06	Urubúes, palomas.	03	---	---	Pájaros	06
Tecnológicos	Las cometas, Cohete	06	Helicóptero, la cometa.	08	---	---	Avión	02

Tabla 1. Categorización de las respuestas de la cuestión 1 del grupo Testeo y Control cuanto a lo que existe en el Cielo

La representación del grupo testeo y control cuanto al número de respuestas, considerando que algunos alumnos respondieron más de un tipo de elemento, nos muestra: Dispersión de las manifestaciones verbales en el grupo testeo cuanto a los elementos; Inclusión de elementos biológicos y tecnológicos en la Evaluación de Aprendizaje del grupo control; Reducción de respuestas relacionadas a los elementos cultural/religiosos en el grupo testeo, comparando LP y AP; Estabilidad de respuestas relacionadas a los Elementos Astronómicos en el grupo testeo y la disminución de los demás elementos, comparando LP y AP. De esa forma, con la intervención el grupo testeo buscó utilizar, con menor dificultad, los conceptos científicos (EA) para contestar a estas cuestiones. Ya el grupo control presentó un aumento de respuestas referente a los EA, pero también, un aumento de respuestas referentes a otros elementos no astronómicos. Percibimos que el grupo control, presentó más dificultad en utilizar los conceptos sobre el tema enseñado durante la intervención, demostrando, según aclara Moreira (2008), la necesidad de estrenar las interacciones entre el conocimiento previo, específicamente relevante, existente en la estructura cognitiva de ese alumno y el nuevo conocimiento, para que finalmente ocurra el aprendizaje significativo.

Cuanto al movimiento aparente del Sol, en lo que se refiere a la identificación de ese movimiento, constatamos que no hubo una diferencia distintiva en los conocimientos de los dos grupos, es decir, los 2 grupos no presentaron evolución expresiva de la respuesta correcta (NO) entre las evaluaciones diagnosis y de aprendizaje. Eso evidencia que el mapa conceptual puede no ser potencialmente significativo para el desarrollo de todos los conocimientos necesarios a la comprensión del tema. Por eso, debemos insistir en su utilización, visto que, el uso constante en clase, favorece a la adquisición de conceptos aceptados en el contexto de la materia de enseñanza por medio de otra habilidad, como el aprender a aprender (Novak y Gowin, 1999). Sin embargo, comparando los grupos, observamos que el grupo testeo presentó una diferencia muy pequeña en el número de alumnos que identifican el movimiento aparente del sol, eso demuestra la necesaria efectividad en el uso del mapa conceptual.

Pensando en nivel de indicadores de aprendizaje, resaltamos que el grupo testeo obtuvo un aumento de 5% de alumnos que identifican y hacen uso del lenguaje científico y que el grupo control obtuvo un aumento de 4%, podemos inferir que no hubo una diferencia expresiva entre los grupos tras la intervención, en lo que se refiere a este indicador de aprendizaje (identificación del movimiento aparente del Sol).

En función de las respuestas a la cuestión "¿Dónde está el Sol durante la noche?" el grupo testeo obtuvo un aumento de 5% de alumnos que identifican el movimiento aparente del Sol y hacen uso del lenguaje científico, es decir, en relación a la evaluación diagnóstica y la de aprendizaje, el aumento de alumnos del grupo testeo que evolucionó no fue considerado tan expresivo. Ya en el grupo control, el aumento de 11%, manifiesta mayor expresividad de conocimiento para esa cuestión, evidenciando que los significados relativos a esta fueron captados, aun no haciendo uso del mapa conceptual. Tal situación no corrobora con investigaciones realizadas sobre el potencial del mapa conceptual en relación a otros recursos didácticos, como por ejemplo, lectura e interpretación de textos sobre el tema que se desea enseñar.

Cuanto al indicador de aprendizaje "Caracterización y diferenciación de los astros pertenecientes al Sistema Solar" se analizó la capacidad del alumno en representar un modelo de Sistema solar con sus astros, identificados por sus formas, ubicaciones, tamaños y distancias, por medio de dibujos. En la evaluación diagnóstica, la mayoría de los alumnos del grupo testeo no representó adecuadamente los astros. Tras la intervención, observamos un aumento considerable de esas habilidades en la evaluación de aprendizaje auxiliadas por conceptos científicos trabajados durante el desarrollo del contenido. En relación al grupo control, también hubo aumento de esa habilidad, en la misma proporción y en las mismas condiciones. Sin embargo, al denominar los elementos del sistema solar notamos mayor expresividad en el grupo testeo.

Se vuelve claro, por el análisis hecho hasta ahora, que son tenues las diferencias de aprendizaje de los dos grupos, tras la intervención. Por otro lado, la utilización del mapa conceptual como recurso facilitador del aprendizaje de los conceptos del tema Tierra y Universo, permitió estructurar la red de conceptos, ideas y las proposiciones más generales e inclusivas del contenido. Así como, explotar las relaciones entre las ideas, distinguir diferencias y semejanzas que sostienen la comprensión de los alumnos sobre el tema (Moreira, 2008).

Cuestión	*Utilizó los conceptos científicos*				*Utilizó conceptos no científicos*				*No contestó de acuerdo*			
	Diagnosis		Aprendizaje		Diagnosis		Aprendizaje		Diagnosis		Aprendizaje	
	Respuestas	%	Respuestas	%	Respuestas	%	Respuestas	%	Respuestas	%	Respuestas	%
5b	Rotación	05	Rotación, traslación	10	Tierra gira, no sale del cielo, ilumina la otra parte del planeta.	42	Planeta gira, otro lugar.	42	Se esconde; ilumina los demás planetas; atrás de las nubes.	53	Otro lugar; no contestó.	48
5c	Otro lado del mundo; Ilumina otro lugar de la Tierra; gira alrededor de la Tierra	57	No sale del lugar; otro lado de la Tierra; ilumina otro lado del planeta.	62	Queda en Japón;	05	Otros países	05	no sé; otro país; para donde está la noche; mundo gira.	38	Otro lado del mundo/Tierra; no sé; otro país; atrás del Sol.	33

Tabla 2. Categorización de las respuestas del grupo Testeo: cuestiones 5 (cuanto a la Ubicación del Sol)

Cuestión	*Utilizó los conceptos científicos*				*Utilizó conceptos no científicos*				*No contestó de acuerdo*			
	Diagnosis		**Aprendizaje**		Diagnosis		Aprendizaje		Diagnosis		Aprendizaje	
	Respuestas	%	Respuestas	%	Respuestas	%	Respuestas	%	Respuestas	%	Respuestas	%
5b	---	---	rotación	**04**	planeta gira tierra gira en su eje está claro tierra gira alrededor del sol	**15**	gira alrededor del sol; planeta gira; está en otro lugar; por la noche está del otro lado del mundo; cuando el sol se va, entra la luna;	**31**	el día tiene que estar claro; porque brilla; alumbra el día; escondido hasta que la noche acabe; deja claro y ayuda a despertarse; se esconde; no contestó.	**85**	está atrás iluminar nubes; cubren el sol día queda sin calor; porque es día para calentar; de día es claro; de día él aparece.	**65**
5c	otro lado del mundo	**31**	en el cielo; otro lado del planeta; alumbrandel otro punto de la tierra.	**42**	queda atrás del planeta en Japón	**04**	la noche desaparece	**08**	cubierto por la oscuridad; cubierto por las nubes; descansando en el cielo; detrás de la luna; detrás de los planetas; no contestó	**65**	cambio de lugar con la luna; debajo de las nubes; va a escansar; se esconde atrás de los planetas.	**50**

Tabla 3. Categorización de las respuestas de las cuestiones 5 del grupo Control cuanto a la Ubicación del Sol

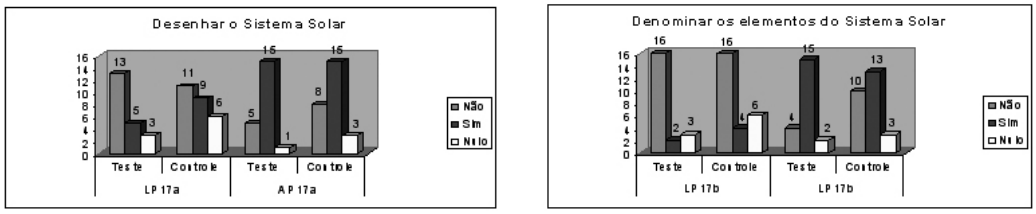


Figura 1. Caracterización y diferenciación de los astros pertenecientes al Sistema Solar

La situación verificada en el análisis de los datos sugiere que, para la presente investigación los instrumentos cuantitativos son insuficientes para evidenciar la contribución de los Mapas Conceptuales para el proceso de adquisición de conocimiento en Ciencias Naturales de este grupo, siendo necesario utilizar de forma complementaria instrumentos de evaluación cualitativa. Esto se vuelve relevante, en la medida en que observamos algunos mapas conceptuales de los alumnos.

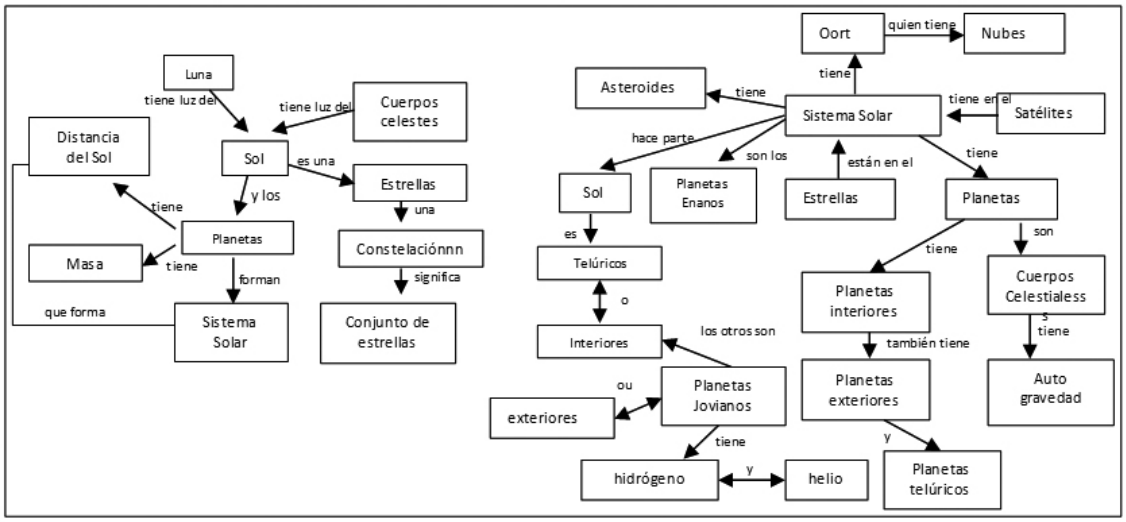


Figura 2. Ejemplos de mapas conceptuales elaborados por alumno 19 del grupo testeo, durante la intervención.

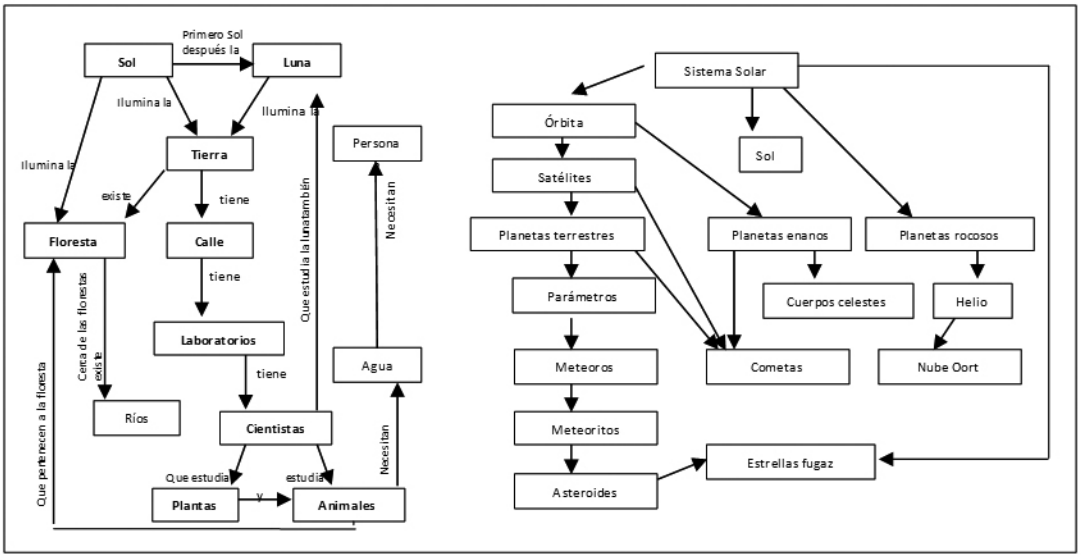


Figura 3. Ejemplos de mapas conceptuales elaborados por alumno 32 del grupo testeo, durante la intervención.

5 Consideraciones finales

Considerando lo presentado en estos resultados parciales, aseguro la necesidad de un análisis cualitativo de los mapas conceptuales elaborados por los alumnos de grupo de testeo. El análisis cualitativo muestra otra forma de entender los significados atribuidos por los alumnos en la confección del mapa. La experiencia nos demuestra que sería posible utilizar los resultados de la evaluación de diagnóstico como criterio de selección de los grupos con características similares por los investigadores que no actúan como un maestro del grupo estudiado. Para mejorar nuestro análisis del sistema de evaluación se recomienda para el cálculo de la "t" de Student para el nivel de significancia elegido, utilizando tablas estadísticas calculadas con anterioridad.

En esta etapa, los conceptos de Tierra y Universo que componen los contenidos de la disciplina Ciencias Naturales necesitan ser repensados en un abordaje Ausubeliano en su verdadero sentido también en los años iniciales de la enseñanza Fundamental, buscando construir subsunsores integradores de los conceptos, por medio de métodos adecuados y previamente estudiados.

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A REVIEW OF SEMI-AUTOMATIC APPROACHES TO BUILD CONCEPT MAPS

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Abstract. Concept Maps are graphical tools for knowledge organization and representation. In this decade, we have seen an increasing interest in building concept maps from data sources by applying computational resources, setting out to overcome the issues related to building them from scratch. Nevertheless, we have observed an absence of consistent references, which could allow for a unified vision of this research field. Therefore, considering this gap, we put forward, in this article, a set of classes, organized according to some perspectives, to analyze semi-automatic approaches for building of concept maps. This paper is a part in a research concerned with the use of concept maps in e-learning.

1 Introduction

Concept Maps are graphical tools for knowledge organization and representation (Novak & Cañas, 2006b). Concept Maps elements are defined as concepts – usually labeled by a couple of words inside a circle or a rectangle – and relationships which link two concepts to create a meaningful statement or proposition (Novak & Cañas, 2006a). A concept map can be built manually. However, the construction without computer aided tools are, generally, time consuming and complex. Consequently, there is a great enthusiasm in the use of software applications in order to promote better experiences to those working with concept maps. In addition, with the popularization of the Internet, some tools have developed and have supported really collaborative experiences, making possible the arising of new practices with concept maps (Novak & Cañas 2006a). Daley et al. (2008) noticed that concept maps have been used as knowledge representation tools in many fields, beyond the formal education boundaries, such as in software engineering processes, process and system modeling, human resources processes, and scientific research.

Over the last decade, academic community has developed an increasing interest in applying computational resources to building concept maps from different data sources. Research in this field focuses on two major challenges: (i) to overcome the difficulties in concept maps building from scratch, and (ii) to reduce the time and effort in knowledge acquisition activities in large domains highly dependent on experts (Chang et al., 2008; Lee et al, 2000). Even though the most research in building of concept maps had been introduced as "automatic approach", in our humble opinion, at least for now, the expression "semi- automatic approach" is more appropriate, given their considerable dependency on human interventions throughout the building process.

The majority of approaches to build concept maps from data sources was encouraged by educational issues among which we mention: the use of concept maps in teaching-learning process (Alves et al., 2001; Clariana & Koul, 2004; Lau et al., 2008), in selection of teaching strategies (Chang et al., 2008;Chen et al., 2008; Bai & Chen, 2008; Lee et al., 2009; Tseng et al., 2007), and in evaluation of students (Graudina & Grundspenkis, 2008;Villalon & Calvo, 2008). Other research projects had different motivations to use concept maps, of which we might highlight the following uses: to represent knowledge in a friendly way, especially for domain experts (Kumazawa et al., 2009); to support domain knowledge acquisition (Zouaq & Nkambou, 2008; Zouaq & Nkambou, 2009; Pérez & Vieira; 2004; Pérez & Vieira, 2005); to summarize digital libraries contents (Richardson & Fox, 2007) and to search an share digital documents (Gaines & Shaw, 1994; Valerio & Leake, 2006). In particular, we have interest in the practices with concept maps in educational contexts, especially in e-learning environments. Throughout our research, we have identified that there were not consistent references to allow us to compare the most significant semi- automatic concept maps building approaches. As a consequence, aiming to fulfill this gap, we try to propose, in this paper, a set of classes[1] , acting as a minimal reference, to outline concept maps building approaches by means of different perspectives. This minimal

reference is supported by a review of academic publications occurred between 1994 and 2009 that, explicitly, stated the purpose of building concept maps from data sources in an automatic or semi-automatic mode.

We organized this paper as follows: in Section 2 we underline the particularities of concept maps as knowledge representation language; in Section 3, we propose a classification to semi-automatic concept maps building approaches; in Section 4 we point out our preliminary observations about this research; at last, in Section 5, we conclude with some findings and try to scratch the surface of this area of research outlining some of our future intentions.

2 Concept Maps: Structure and Theoretical Foundations

Compared to others knowledge representation languages based on maps, Concept Maps differ from them with respect to their theoretical basis, their semi-hierarchical organization and the presence of meaningful linking words to connect two concepts (Cañas et al., 2003). Novak & Gowin (1984) founded the concept maps language on the Meaningful Learning Theory (Ausubel, 1963), emphasizing the idea of "subsumption" in learning process. In few words, "subsumption" is a phenomenon that occurs during the learning process, when a learner, supported by an appropriate environment, could be able to attach new concepts to those existent inside his/her cognitive structure (Cañas et al., 2003a). Hence, from the theoretical assumptions, the main features of concept maps were derived: a) concepts should be organized in a semi-hierarchical way in which the general one subsumes a more specific one; b) concepts should be labeled by a couple of words that should define "a perceived regularity in events or objects, or records of events or objects" (Cañas et al., 2003a); c) the relationship between two concepts must be labeled in a form so that propositions could be identified.

3 A Review of Concept Maps Building Approaches

In this section, we intend to put forward a set of classes we propose as a common basis for the analysis of semi-automatic concept maps building approaches. We organized these classes according to different perspectives:

a) Research Goals: What are the research goals? Who are the audience of the resultant concept maps?

b) Data Sources: What kind of data source was used? What methods and techniques were used to handle it? Does the data source belong a specific domain of knowledge?

c) Outputs: How the resultant output looks like? What tools were used to build the output? How the approaches assess the resultant output?

A view of perspectives and respective classes are depicted by Figure 1. Along this section, we define each one of them and also carry on a review of academic publications related to semi-automatic concept maps building.

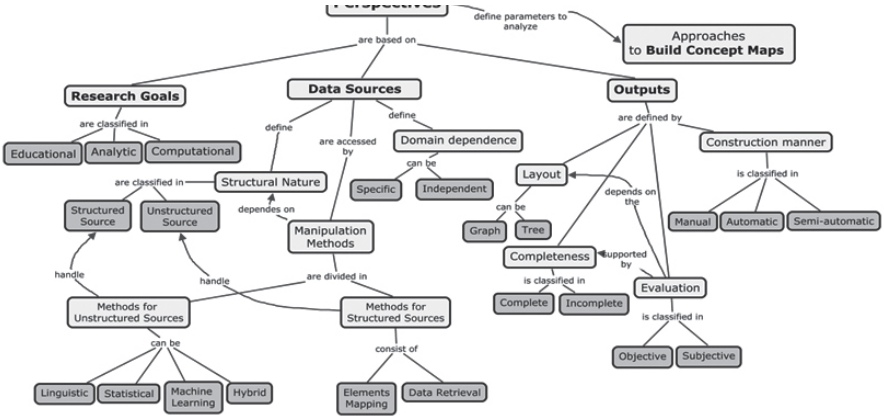


Figure 1. Classes for Analyzing the Approaches to Build Concept Maps

[1] In this paper, we used the term "class" with a sense of "division". Thus, in this paper "class" represents a label used "to outline approaches according to a particular perspective", and it must not be confused with the definition of "class" used in Software Engineering.

3.1 Research Goals Perspective

The goals established by research to build concept maps guide the choice of data sources and define a wide range of requirements, such as: the target audience, the degree of readability, the richness of propositions, etc. We propose the following classes according to the research goals perspective: educational, analytical and computational.

In the educational class the main research goal is the use of concept maps as complement resource in learning process. Among the approaches that fit in this class, we can mention those that:

a) promote interactive construction of concept maps (Alves et al., 2001; Clariana & Koul, 2004);

b) allow teachers to keep track of student comprehension about a specific topic presented in traditional learning environments (Graudina & Grundspenkis, 2008) or in e-learning environments (Lau et al., 2008);

c) sum up and share digital content (Richardson & Fox, 2007; Richardson et al.; 2008).

Analytical class is characterized by the use of concept maps as tools for domain experts that conduct activities of exploration, analysis, and pattern recognition in large data sources. This is the context of approaches that:

a) explore students' historical data, searching for learning patterns (Bai & Chen, 2008; Chang et al., 2008; Chen et al., 2008; Lee at al., 2009; Tseng et al., 2007);

b) display the information to domain experts (Gaines & Shaw, 1994; Kumazawa et al., 2009; Pérez & Vieira 2005; Pérez & Vieira; 2005);

c) propose concept maps as tools for accessing, searching and analyzing data in digital libraries (Valerio & Leake, 2006).

In computational class the core thread consists of handling concept maps as a source for knowledge acquisition by way of software applications. In this class fits the research of (Zouaq & Nkambou, 2008; Zouaq & Nkambou, 2009) that consider concept maps as intermediate representation between text and domain ontologies.

3.2 Data Source Perspective

The data source[2] used by an approach impacts the whole concept map building process. As an input, its structural nature acts both as parameter to select the manipulation method to handle it, and as constraint to determine the degree of domain dependence. Thus, under the top level perspective, we defined classes according to specific points of view, listed as follows: (i) structural nature; (ii) manipulation method, and (iii) domain dependence.

3.2.1 Structural Nature Perspective

The structural nature of data source is defined by the data organization. From this standpoint, data sources used by the approaches could be classified as structured and unstructured. In unstructured data sources, texts in natural language are the primary sources for extracting concept maps elements. Among the approaches that use unstructured data, we could mention those that work with:

a) texts written by domain experts (Alves et al., 2001; Gaines & Shaw, 1994; Valerio & Leake, 2006; Zouaq & Nkambou, 2008; Zouaq & Nkambou, 2009),

b) texts produced by students in response to questionnaires (Chang et al., 2008) or written freely as a discourse related to a given issue (Clariana & Koul, 2004);

c) scientific texts as, for instance, academic articles (Chang et al., 2008), abstract of theses and dissertations (Richardson et al., 2008);

d) messages from forums (Lau et al., 2008);

e) news and textbooks (Pérez & Vieira, 2004; Pérez & Vieira, 2005).

In structured data sources there is some level of formalism in the organization of data. Concept models and implementations of ontologies are examples of structured data sources and they may be seen in the approaches that use tabulation of student productions (Bai & Chen, 2008; Lee et al., 2009; Tseng et al., 2007) and in those that use domain ontology (Graudina & Grundspenkis, 2008; Kumazawa et al., 2009).

[2] If there are more than one data source referred, we should consider only the primary source, i.e., the data source used by the approach to extract concept and relations. Thus we should ignore the features of auxiliary sources, generally applied for lexical purposes, and consulted in complementary activities, such as, for example, words disambiguation, synonym identification and part-of-speech tagging.

3.2.2 Methods Perspective

The link between methods, computational techniques, and structural nature of data source, applied in the automatic construction of concept maps, distinguishes direct classes: methods for unstructured data sources and methods for structured data sources.

Methods for handling unstructured data sources have closer association with issues from Natural Language Processing and all of them could be, by this single criterion, equally identified as linguistic methods. However, the mere presence of linguistic techniques is not enough to describe the whole approach (Manzano-Macho & Gómez-Pérez, 2005). That is the reason our research considers the main technique used by the approach to discover knowledge from texts. The classes of methods are qualified as Linguistic methods, Statistical methods, Machine learning methods and Hybrid methods.

Linguistic methods class is characterized by the presence of techniques from computational linguistics (Manzano-Macho & Gómez-Pérez, 2005). They use morphology, syntactic, semantics, pragmatics, and discourse resources to handle the data source. Linguistic methods are very directly related with text structure and are based on linguistic patterns recognition. They make use of grammars, thematic roles, and named entity recognition. In general, linguistic methods are more accurate than Statistical methods, but generally they need be helped from external knowledge databases, such as dictionaries, thesaurus or lexical data sources (Zouaq & Nkambou, 2009). In this class we could find the approaches of Pérez & Vieira (2004; 2005), Richardson & Fox (2007), and Richardson & Fox (2008).

In Statistical methods class, we may observe the use of techniques based on quantitative indicators (Manzano-Macho & Gómez-Pérez, 2005). Generally, such techniques produce information for analyzing the frequency of a term and co-occurrences between terms in documents or corpus. The most popular techniques are the analysis of frequency of repetition of words or word patterns, the calculation of weights that indicates the relevance of terms in a set of documents (TF-IDF), and clustering techniques for documents. The advantages of statistical methods are their simplicity to handle documents independently from linguistic knowledge. Among their disadvantages, unpredictable results and semantic loss during the document handling (Zouaq & Nkambou, 2009) can be pointed out. The approaches of Gaines & Shaw (1994) and Clariana & Koul (2004) belong to this class.

In Machine learning methods class, techniques use machine learning to extract text elements (Manzano-Macho & Gómez-Pérez, 2005). They are generally used together with statistical methods. Examples of methods of machine learning can be found in the algorithms used in discovering co-occurring elements that may characterize association rules, and in the identification of keywords and taxonomies of elements (Zouaq & Nkambou, 2009).

In Hybrid methods class, a combination between linguistic, machine learning and statistical techniques are there so that the dominant technique could not be identified. In this class, we could insert Alves et al. (2001), Lau et al. (2008), Valerio & Leake (2006), Zouaq & Nkambou (2008; 2009).

Methods used to manipulate structured data sources usually apply element mapping and data retrieval techniques. Based on these techniques, we identified two major classes for manipulation of structure data sources: Element mapping methods and Data retrieval methods. Graudina & Grundspenkis (2008) and Kumazawa, Saito, Kozaki, Matsui, & Mizoguchi (2009) approaches can be fit in Element Mapping method class because they perform the mapping of concepts, properties, and associations from domain ontologies to elements of concept maps. The approaches of Bai & Chen (2008), Chen et al. (2008), Lee et al. (2009) and Tseng et al. (2007) do not require a great effort to identify concepts because all the concepts to build a map are defined from the handling of focal questions; thus, they belong to Data retrieval methods class.

3.2.3 Domain Dependence Perspective

According to the domain dependence, we observed that approaches could be classified as domain-independent or domain-specific class. In domain-independent class the selection of data sources are not restricted to a specific domain neither the approach requires an earlier knowledge to deal with it. In this class we might outline the research of (Alves

et al., 2001; Pérez and Vieira, 2005; Pérez and Vieira, 2005; Valerio & Leake, 2006). Approaches in Domain-specific class handle data sources that belong to a specific domain, such as the approaches that deal with: E-learning (Chen et al., 2008), Informatics in Education (Zouaq & Nkambou, 2008; Zouaq & Nkambou, 2009), Anatomy and Physiology of human heart (Clariana & Koul, 2004), Manufacturing Software (Gaines & Shaw, 1994), Computer Science (Graudina & Grundspenkis, 2008; Richardson & Fox, 2007; Richardson et al., 2008), Sustainability Science (Kumazawa et al., 2009). The research of Bai & Chen (2008), Chang et al. (2008), Lau et al. (2008), Lee et al (2009) and Tseng et al. (2007) does not refer to a specific domain, but it is not independent of domain because all the concepts should be defined during the focal question planning.

3.3 The Outcomes Perspective

From the perspective of approaches outcomes, a concept map constructed can be analyzed considering (i) the form of its graphical presentation, (ii) the completeness of its definition, (iii) how it was built, and (iv) the mechanisms used to assess its quality. The graphical layout of a concept map may be directly observed from the concept map. If there is an explicit topology, the concept map belongs to a tree class, otherwise, a graph class. These mathematical structure definitions can be found in Graph Theory (Diestel, 2005).

Completeness of a concept map is evaluated using formal definition of Concept Map, in a sense that a concept map should have understandable concepts and well-formed relations. Here, we could identify two classes: complete or incomplete maps. Maps of incomplete class do not show propositions, generally because labels are not clear enough to build propositions. In maps of complete class propositions are obviously defined.

We may classify approaches according to different manners to build a concept map – we defined this perspective as construct manner. Some of these approaches provide automatic and native resources, while others have interoperability with third-party tools, and also there are those in which the concept map construction procedure is not mentioned. We proposed the following classes of classification: automatic, semi-automatic, and manual representation class. Automatic representation is the class for tools with native resources to automatically build and show concept maps, as in Bai & Chen (2008), Chang et al. (2008), Chen et al. (2008), Kumazawa et al. (2009), Lau et al. (2008), Lee et al. (2009), Tseng et al. (2007) Zouaq & Nkambou (2008; 2009). In the semi-automatic representation class, a set of propositions are produced so that they could be imported by a third-party tool, as observed in Alves et al. (2001), Clariana & Koul (2004), Gaines & Shaw (1994), Graudina & Grundspenkis (2008), Richardson & Fox (2007) and Richardson et al. (2008). In manual representation class, only concepts and relations are extracted from the data source but propositions are not defined. In this last class, we only can build maps manually, using a third-party tool, as in Valerio & Leake (2006).

Concerning the quality of concept maps, we propose classes for evaluation methods used by the concept map building approaches. Evaluating a map consists of validating propositions and elements in a concept map, trying to identify the ill-formed propositions. The classes of evaluation are separated in: Objective or Subjective class. In subjective class, an evaluation is conducted by human experts that use their own criteria to validate concept maps. Sometimes the evaluation given is not repeatable and uniform because it depends on personal feelings. Almost all of the approaches analyzed in our research are skeptical of subjective evaluation. In objective evaluation class, an evaluation could be conducted both by human experts and computational resources because it is founded on rating scores, by defining different rates to propositions, hierarchy levels, quantity of ramifications, cross-links and specific examples, as originally proposed by (Novak & Gowin, 1984). Table 1 summarizes the approaches in classes, according to each of the perspectives.

Reference	*Research Goals Perspective*	*Data Sources Perspective*			*Outputs Perspective*		
		Domain Dependence	*Structure*	*Method*	*Construction Manner*	*Layout/ Completeness*	*Evaluation*
Alves et al. (2001)	Educational	Domain Independent	Unstructured	Hybrid Method	Semi-automatic	Graph Complete	Subjective
Bai et al (2008)	Analytic	Domain Specific	Structured	Data Retrieval	Automatic	Graph Incomplete	Not found
Chang et al. (2008)	Analytic	Domain Specific	Unstructured	Statistical Method	Automatic	Tree Incomplete	Not found
Chen et al. (2008)	Analytic	Domain Specific	Unstructured	Statistical Method	Automatic	Graph Incomplete	Subjective
Clariana and Koul (2004)	Educational	Domain Specific	Unstructured	Statistical Method	Semi-automatic	Graph Incomplete	Objective
Gaines and Shaw (1994)	Analytic	Domain Specific	Unstructured	Statistical Method	Semi-automatic	Graph Incomplete	Subjective
Graudina and Grundspenkis (2008)	Educational	Domain Specific	Structure	Elements Mapping	Semi-automatic	Graph Incomplete	Subjective
Kumazawa et al. (2009)	Analytic	Domain Specific	Structure	Elements Mapping	Automatic	Graph Incomplete	Subjective
Lau et al. (2008)	Educational	Domain Specific	Unstructured	Hybrid Method	Automatic	Graph Incomplete	Subjective
Lee et al. (2009)	Analytic	Domain Specific	Structure	Data Retrieval	Automatic	Graph Incomplete	Subjective
Pérez and Vieira (2004)(2005)	Educational	Domain Independent	Unstructured	Linguistic Method	Not found	Graph Complete	Subjective
Richardson and Fox (2007); Richardson et al. (2008)	Educational	Domain Specific	Unstructured	Linguistic Method	Semi-automatic	Graph Complete	Subjective
Tseng et al. (2007)	Educational	Domain Specific	Structure	Data Retrieval	Automatic	Graph Incomplete	Subjective
Valerio and Leake (2006)	Analytic	Domain Independent	Unstructured	Hybrid Method	Manual	Graph Complete	Subjective
Zouaq and Nkambou (2008)(2009)	Computational	Domain Independent	Unstructured	Hybrid Method	Automatic	Graph Complete	Subjective

Table 1. Classification of semi-automatic approaches to build Concept Maps

4 Data Analysis Results

In this section, we present, by means of charts in Figure 2, some observations derived from data analysis of Table 1. The chart of Figure 2(a) shows that most of the approaches analyzed are recent: 10 of 15 approaches (66.67%) were published in the last three years. Figure 2(b) illustrates that 14 of 15 approaches (93.34%) were concerned with human readers. This number was calculated by the sum of numbers from Educational (46.67%) and Analytic approaches (46.67%). In Figure 2(c), we present numbers that revealed a connection between structure and domain dependence of used data sources. Approaches that have used structured sources were totally domain dependent, but approaches based on handling unstructured sources could be domain independent. Figure 2(d) indicates the tradeoff of the most applied manipulation methods and data sources' structural nature. For unstructured sources, there are three suitable methods: Linguistic, Hybrid and Statistical. In Figure 2(e) we can observe that only Hybrid and Linguistic Methods have produced complete Concept Maps and complete outputs represented just 5 of 15 approaches (33.33%). Finally, in Figure 2(f), other important information can be observed: all of the five approaches that built concept maps that are represented as complete graphs were based in unstructured data sources.

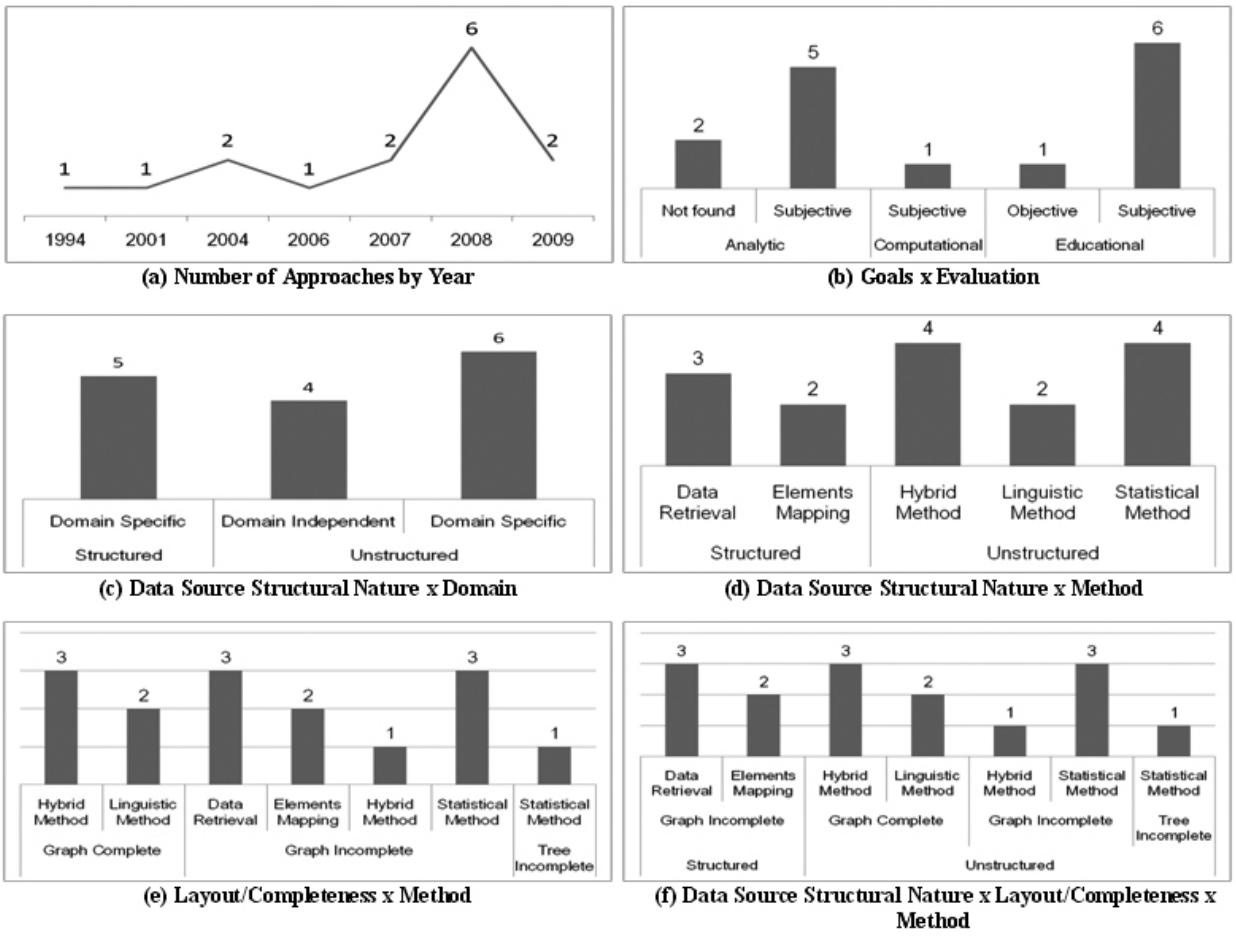


Figure 2 . Data Analysis of investigated approaches

5 Conclusions and Future Works

As we could see in the previous sections, the research in automatic building of Concept Maps has produced interesting results, especially in the works of Alves et al. (2001) and Zouaq & Nkambou (2008; 2009). However, we cannot deny that these approaches are far from being truly automatic. For these reasons we consider the term "semi-automatic" much more appropriate to refer to the approaches investigated, so far. However, we are aware that intense work is being done towards human independence in this process.

Handling unstructured data is a tangible challenge to computer applications. Large amounts of unstructured data are available in the Internet and digital libraries and their contents are increasing every day. So, it is expected that 10 of 15 approaches (66.67%) are concerned with methods for unstructured data.

A curious observation appeared in our research related to domain ontologies: two approaches used Concept Maps as output to represent ontology to human readers (Graudina and Grundspenkis, 2008; Kumazawa et al., 2009). On the other hand, there are approaches that use Concept Maps as intermediate representation between unstructured data and domain ontologies (Zouaq & Nkambou, 2008; Zouaq & Nkambou, 2009). We can assume that, despite of the fact Concept Maps are usually underestimated because of their simplicity and also because of their lack of formalism, they still are very useful to human understanding. We are aware that the set of classes presented here is incomplete and extensions may be added to improve it. This paper should not be understood as a fait accompli, but much on the contrary, we try to propose just a starting point to begin a debate. The next steps of this work will consist of the definition

of a hybrid approach to manipulate texts in Brazilian Portuguese Language to produce complete Concept Maps and its application on e-learning environments. To achieve this result, we are developing techniques to recognize the core elements of concept maps based on linguistic chunks such as Noun Phrases, Verbal Phrases and Prepositional Phrases. Besides, we will try to represent their intrinsic dependency by graphs.

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A TAXONOMIC SCHEME FOR PROPOSITIONAL ANALYSIS

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Abstract. Propositions are the concept maps' building blocks. Despite prepared to answer the same focal question, different authors can produce highly unique concept maps (Cmaps). We propose a taxonomic scheme for classifying propositions into 6 categories to explore in depth the latent information we can obtain comparing a set of Cmaps. We analyzed 55 Cmaps and the results were obtained by using descriptive statistics and hierarchical cluster analysis (multivariate exploratory approach). We characterized 6 clusters containing Cmaps with distinguishable features, which helped to assess the students' understanding about the relationships among science, technology, and society (STS). Cmaps rich in dynamic causative propositions indicated a sophisticated understanding about the STS relationship.

1 Introduction

Concept mapping is a well-established technique that allows knowledge to be graphically represented (Novak, 2010). It has been widely used for teaching and corporate purposes, with a broad range of goals: assessing prior knowledge, eliciting, archiving and sharing expert knowledge, and fostering collaboration are just a few of the practical and educational uses for this technique (Fourie & Westhuizen, 2008; Kyrö & Niskanen, 2008; Novak, 2010; Torres & Marriott, 2009).

Concept maps (Cmaps) can be defined as a set of concepts into a propositional network. Propositions are called semantic units, and they are critical to make clear the mapper's conceptual understanding. The literature has presented some interesting works focused on propositional analysis (Safayeni, Derbentseva, & Cañas, 2005; Miller & Cañas, 2008; Derbentseva, Safayeni, & Cañas, 2007). The combination of the available information has allowed us to improve our capacity to explain the propositions that are present in Cmaps. Static, dynamic causative, and dynamic non-causative are the main categories used to describe propositions (Safayeni, Derbentseva, & Cañas, 2005; Miller & Cañas, 2008; Derbentseva, Safayeni, & Cañas, 2007). Our experience with propositional analysis suggests the inclusion of a parameter to consider how dynamic propositions show the interdependence between the concepts: implicitly, partially explicit, and totally explicit. A taxonomic scheme for classifying propositions is presented in Figure 1.

The aim of this work was to evaluate the use of the proposed taxonomy to classify the propositions (n=825) of Cmaps (n=55) about the relationships among science, technology and society (STS). The STS approach is necessary to change science teaching throughout the formal education, and it should be implemented by using innovative instructional strategies (Bybee & Fuchs, 2006; Correia et al, 2010; DeHaan, 2005; Donnelly, 2004; Holbrook & Rannikmae, 2007; Infante-Malachias & Correia, 2007; Santos, 2007).

2 Research procedures

2.1 Setting and data collection

The Cmaps (n=55) considered in this work were obtained during the ACH 0011 Natural Sciences course, which is offered for all first-year students at Escola de Artes, Ciências e Humanidades (School of Arts, Science and Humanities at São Paulo University). The main goal of this course is to provide a comprehensive view of the impact caused by scientific and technological development in our society (Correia et al, 2010). Sixty students from four different undergraduate courses were grouped in one classroom, for two-hour weekly classes over a period of fifteen weeks.

Considering the introductory scope of Natural Sciences course and the diverse audience, the challenge to satisfy students' expectations required innovative methodological strategies.

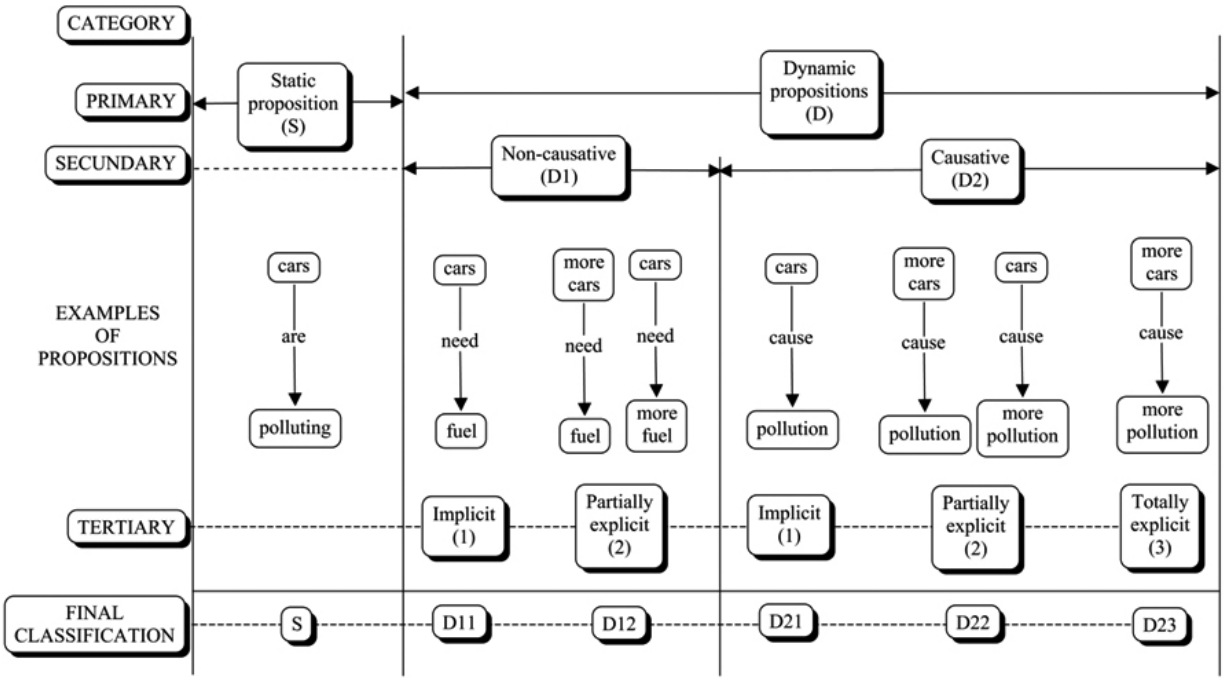


Figure 1. Taxonomic scheme for classifying propositions. Primary categories: static (S) and dynamic (D); secondary categories: non-causative (D1) and causative (D2); tertiary categories: implicit (1), partially explicit (2), and totally explicit (3).

Students were introduced to concept mapping and trained to elaborate both manuscript and digital Cmaps using the Cmaptools software at the beginning of the ACH 0011 course (Correia, Infante-Malachias, & Godoy, 2008). The aim was to ensure a reasonable training session for students in order to avoid the inappropriate use of concept mapping, as highlighted in the literature (Cañas & Novak, 2006; Correia, Infante-Malachias, & Godoy, 2008).

Bioethics was the main issue discussed at the end of the ACH 0011 course (classes 11-15). Table 1 summarizes part of the course schedule, showing when discussions about bioethics took place and the assigned activities using Cmaps. The conceptual framework explored in these classes involved evolution and the origin of life (class 11), DNA and molecular biology (class 12), medical implications of molecular biology (class 13), and the Brazilian biosecurity law (class 14). The final course test (class 15) involved the individual construction of a half-structured concept map (HSCmap) with 9 concepts to address the following focal question: "How does bioethics regulate the relationship between science and society?". The concepts "more controversy" and "more technology" were imposed to the students, and they must be present in their HSCmaps (Figure 2). Both the how-type focal question and the quantified concepts are strategies to promote dynamic, rather than static propositions (Derbentseva, Safayeni, & Cañas, 2007).

Class #	Pedagogical activities	Cmap activities
11	Preparatory reading assigned *"Explaining the very improbable" (Dawkins, 1996)*	Individual Cmaps about the preparation reading (before the class) Collaborative Cmaps (after the classroom discussions)
12	Preparatory reading assigned *"Science, Genetics and Ethics: Memo for Tony Blair" (Dawkins, 2004)*	Individual Cmaps about the preparation reading (before the class) Collaborative Cmaps (after the classroom discussions)
13	Film session: episode 1 of *"DNA, the promise and the price" (Discovery Channel)*	-
14	Brazilian Biosecurity Law	Collaborative Cmaps about the discussion during the classes 13-14
15	ACH 0011 course final test	Half-sctructured concept map (HSCmap) to answer "How does bioethics regulate the relationship between science and society?" Obligatory concepts: more controversy and more technology

Table 1. Pedagogical organization of the activities about bioethics during ACH 0011, Natural Sciences course.

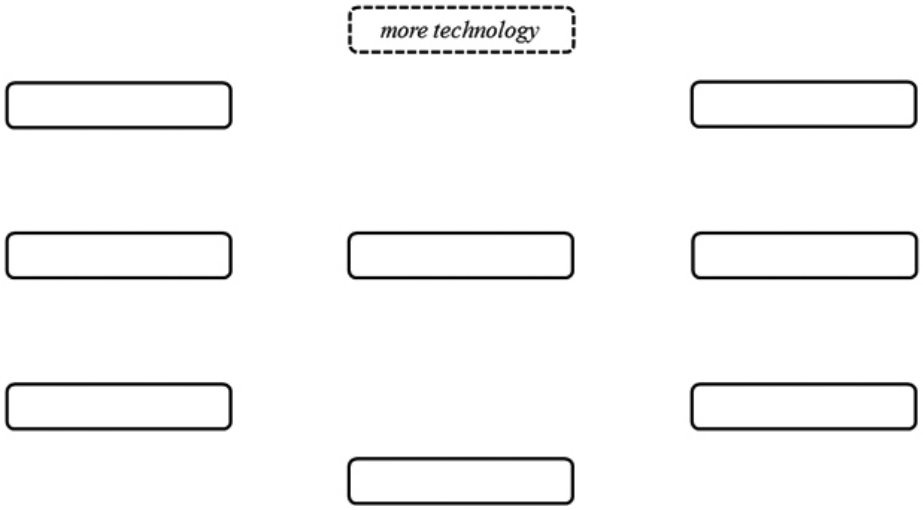


Figure 2. HSCmap with 9 concepts used in the final test of the ACH 0011 course. The concepts "more controversy" and "more technology" were obligatory, and the latter was positioned as the starting concept of the HSCmaps.

2.2 Propositional analysis of HSCmaps

Several works dealing with rubrics for evaluating the semantic features of propositions were recently proposed (Derbentseva, Safayeni, & Cañas, 2007; Miller & Cañas, 2008; Safayeni, Derbentseva, & Cañas, 2005). Inspired by those ideas, we devised the taxonomic scheme presented in Figure 1. The analytical method to classify each proposition into one of the proposed categories (S, D11, D12, D21, D22, and D23) is described in Table 2. A 4-question sequence was enough to make an appropriate choice.

Focus on	Category	Questions to classify the propositions	Response	Action	Result
LINKING PHRASE	Primary	#1. Does the linking phrase have a verb?	Yes	See question #2	-
			No	Static proposition	S
		#2. Is the verb an auxiliary one *(e.g. be, do , have)*?	Yes	Static proposition	S
			No	Dynamic proposition	D
CONCEPTS	Secondary	#3. Do both initial and final concepts indicate cause and consequence, respectively?	Yes	See question #3 Dynamic, causative proposition See question #4	D2
			No	Dynamic, non-causative proposition See question #4	D1
	Tertiary	#4. Are the concepts quantified *(e.g. more cars, many cars)*?	Both concepts	Totally explicit (3)	D23
			Only one concept	Partially explicit (2)	D12, D22
			None	Implicit (1)	D11, D21

Table 2. Procedure for classifying propositions into the taxonomic scheme categories.

2.3 Data analysis

2.3.1 Descriptive statistics

Box-plot graphs were used to show the statistical parameters (average, median, lower quartile, upper quartile, sample minimum, and sample maximum) obtained to describe each variable considered in our analysis (S, D11, D12, D21, D22, and D23). These graphs allow checking the central tendency, the symmetry, and the dispersion of a data set at a glance (Cohen & Lea, 2004).

2.3.2 Cluster analysis: multivariate statistics

A data matrix X(55,6) containing all data from the propositional analysis was used to carry out hierarchical cluster analysis (HCA). HCA is an exploratory statistical method to classify objects (concept maps) into groups according to their similarities (Kaufman & Rousseeuw, 2005). All variables (n=6) are taken into account and this multivariate approach fits well to unveil latent information. Statistica 8 (StatSoft, Tulsa, OK, USA) was the software chosen to perform this analysis. The graphical output of HCA (dendrogram) will be used to discuss the results in the next section.

3 Results and discussion

3.1 Propositional analysis at a glance: frequency distribution to the devised categories

The 55 HSCmaps presented 825 propositions that were classified as indicated in Table 3. More than 80% of all propositions were classified as dynamic, and causative propositions (43.1 %) were slightly more frequent than non-causative (39.7 %). These results suggest the strategies adopted to promote dynamic rather than static propositions were effective. The propositions using the obligatory concepts were removed to evaluate the impact of the how-type focal question. The subset A was obtained after removing all propositions containing "more technology", and the subset B was obtained after removing all propositions containing both "more technology" and "more controversy". The comparison of subsets A and B with the full set of propositions showed a decrease in the proportion of D12, D22 and D23, while the amount of static propositions, D11 and D21 increased. The 3:1 ratio for dynamic (74.5%): static (25.5%) propositions observed in subset B was primarily due to the use of a how-type focal question (Table 3).

Proposition sets	Static propositions	Dynamic propositions				
		D11	D12	D21	D22	D23
Full (n=825)	142 (17.2%)	261 (31.6%)	67 (8.1%)	97 (11.8%)	191 (23.2%)	67 (8.1%)
A (n=680)	140 (20.6%)	260 (38.4%)	34 (5.0%)	97 (14.3%)	126 (18.5%)	22 (3.2%)
B (n=548)	140 (25.5%)	260 (47.4%)	13 (2.4%)	97 (17.7%)	33 (6.0%)	5 (0.9%)

Table 3. Frequency distribution of the analyzed propositions into the proposed categories.

3.2 Box-plots for the devised categories

Figure 3 presents the box-plots obtained for each category proposed in this work. The average (Av) and the median (Me) of static propositions (S) were 3±2 and 2, respectively. The category D11 presented the highest values among all D-categories (Av=5±3; Me=4), while the categories D12 (Av=1±1; Me=1), D21 (Av=2±2; Me=1), and D23 (Av=1±1; Me=1) presented lower values than S. The category D22 (Av=3±2; Me=3) presented similar values in comparison with S.

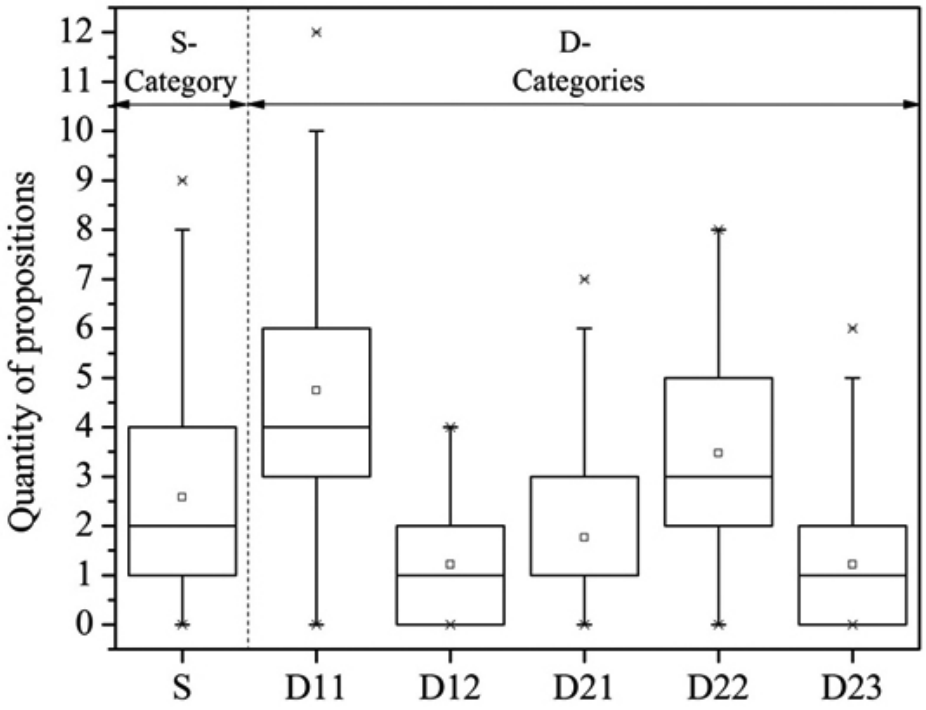


Figure 3. Box-plot obtained for each category of the propositional analysis under investigation. S-Category refers to static propositions; D-Categories refer to dynamic propositions.

3.3 Finding patterns through cluster analysis

Hierarchical cluster analysis (HCA) was used as a multivariate exploratory analysis (Kaufman & Rousseeuw, 2005). The entire data set was organized into as a matrix X(55,6). Several parameters were tested in order to achieve the most significant clusters, considering our knowledge on concept mapping. Distances between objects (HSCmaps) were measured using single, complete, and Manhattan (or City-Block) methods. Distances between clusters were measured using Euclidean and Ward's methods. The dendrogram presented in Figure 4 was obtained using Manhattan and Ward's methods for measuring distances between objects and clusters, respectively. An arbitrary value corresponding to 40% of de maximum distance between 2 objects (Cmaps) was chosen to describe the clusters to be compared. The dotted line in Figure 4 helps to identify 6 clusters (I-VI).

Despite the descriptive parameters presented in Figure 3 for all Cmaps (n=55), the average number of propositions for each group (S, D11, D12, D21, D22, and D23) was calculated for each cluster. The differences between clusters can be discussed from the data presented in Table 4. The use of black dots was a choice to make easier to compare the recognizable features of each cluster. In spite of all quantitative manipulations of the data, the qualitative approach dominates when HCA is used. Therefore, the information in Table 4 is presented in a friendly graphical manner.

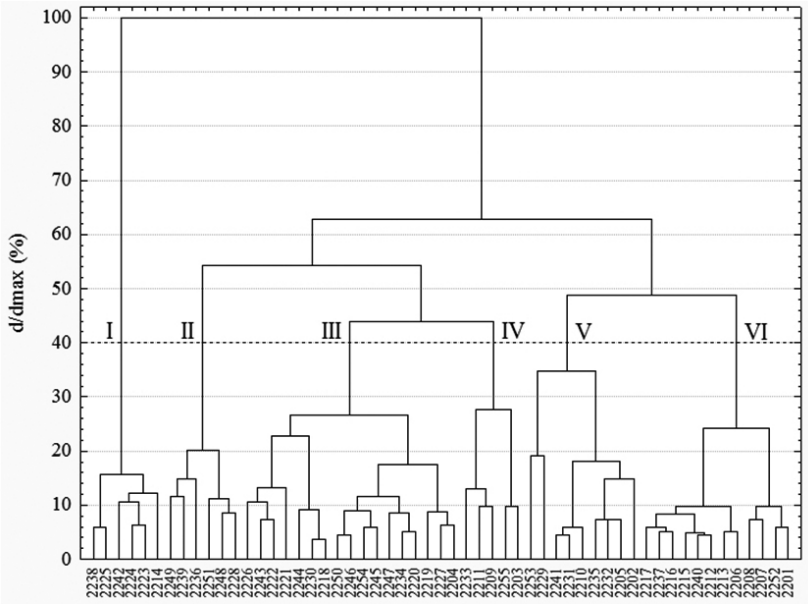


Figure 4. Dendrogram obtained by HCA considering the full data matrix X(55,6). Selected parameters for running HCA: Manhattan (or City Block) distance to measure between CMaps distance; Ward distance to measure between clusters distance. An arbitrary value of 40% of the maximum distance (dmax) was selected to compare the characteristics of the obtained clusters (I-VI).

	Cluster ID	**I**	**II**	**III**	**IV**	**V**	**VI**
	# of CMs	*6*	*6*	*17*	*5*	*9*	*12*
Categories for propositional analysis	*S*	•	•	••	••••	•	•
	D11	••••	•	••	••	•••	•••
	D12	••••	••	•••	••	•	••
	D21	••	••	••••	••	••••	•
	D22	•••	•••	•••	•••	••••	•
	D23	••	•••••	•	•••	••	•••

Table 4. Differences between clusters explained by the categories used for propositional analysis. The number of black dots indicates the relative average magnitude for each cluster. Highest values (••••), lowest values (•), intermediate values (••) or (•••).

The highest average values (••••) highlighted the differences between the clusters I (D11 and D12), II (D23), IV (S), and V (D21 and D22). The lowest average values (•) were useful to characterize the cluster VI (S, D21, and D22), and cluster III (D23). Intermediate values (••/•••) can be used to improve the description among clusters I-VI. The categories proposed in our taxonomic scheme for propositional analysis made possible to interpret the result obtained from HCA (Figure 4).

- Cluster I contains Cmaps rich in dynamic, non-causative propositions partially explicit/implicit (D11, D12).
- Cluster II contains Cmaps rich in dynamic, causative propositions totally explicit (D23).
- Clusters III and V contain Cmaps rich in dynamic, causative propositions partially explicit/implicit (D21, D22).
- Cluster IV contains Cmaps rich in static propositions (S).
- Cluster VI contains Cmaps with sorted propositions.

3.4 Illustrative concept maps

Figure 5 shows representative Cmaps to illustrate the main features presented by the clusters I, II, and IV.

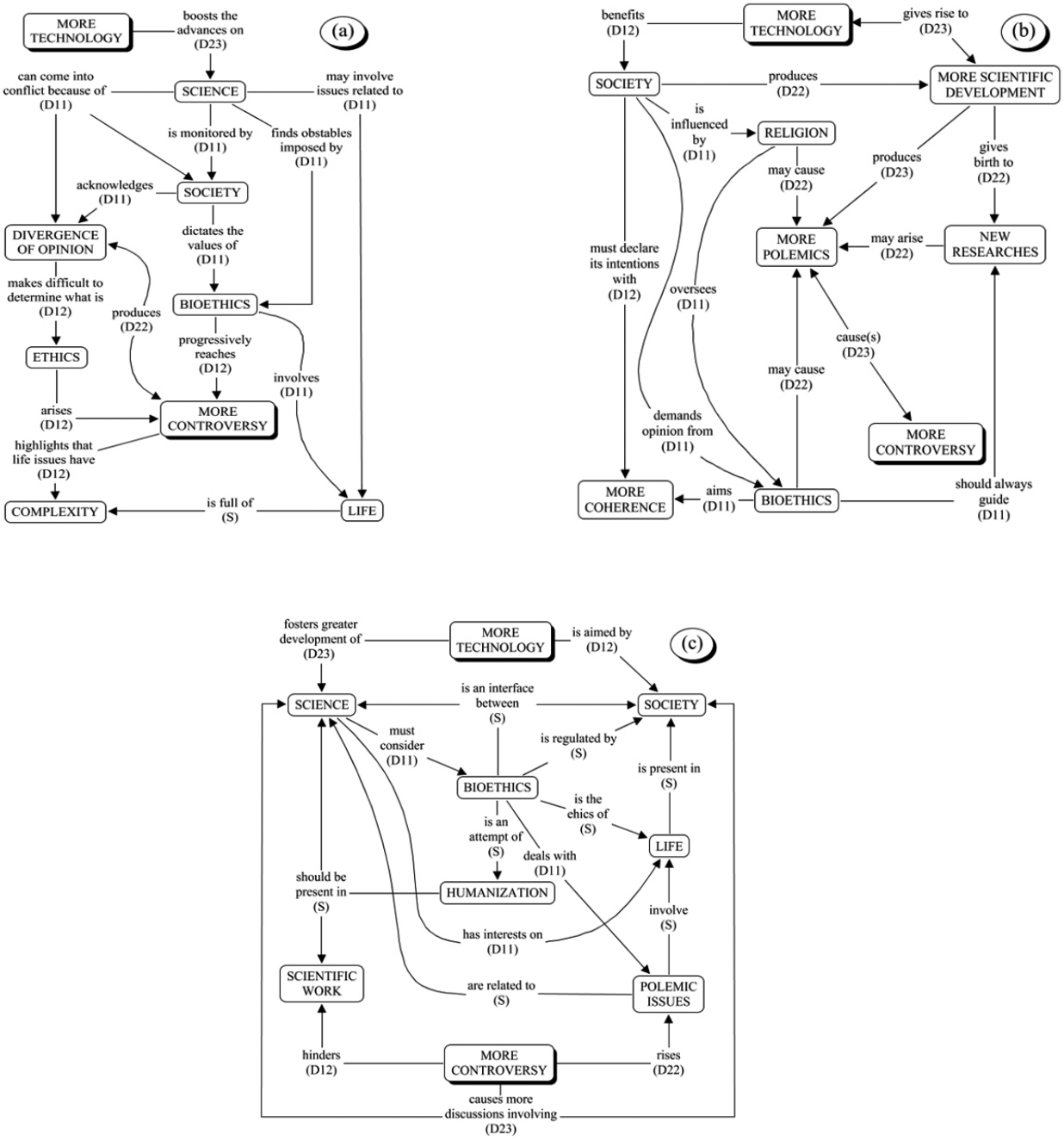


Figure 5. Selected Cmaps prepared by the students during the final course test: (a) cluster I (mainly D11 and D12 propositions), (b) cluster II (mainly D23 propositions), and (c) cluster IV (mainly S propositions).

All Cmaps in Figure 5 have a high proposition/concept ratio (Figure 5a: 1.78; Figure 5b: 1.89; Figure 5c: 2.11). The students could manage Cmaps with extremely dense networks, confirming they were well training at the beginning of the course. Most propositions in Figure 5a were classified as dynamic and non-causative, indicating the student went beyond the mere description of the concepts:

- more technology - boosts the advances on → science (D23)
- science - is monitored by → society (D11)
- science - can come into conflict because of → divergence of opinion (D11)

- society - acknowledges → divergence of opinion (D11)
- society - dictates the values of→ bioethics (D11)
- bioethics - progressively reaches → more controversy (D12)

The cause-consequence relationship among concepts was even more obvious in Figure 5b. The author mainly used dynamic and causative propositions, and the dynamic thinking is expressed throughout the Cmap network:

- more technology - benefits - society (D12)
- more technology - gives rise to - more scientific development (D23)
- more scientific development - gives rise to - more technology (D23)
- more scientific development - gives birth to - new researches (D22)
- new researches - may arise - more polemics (D22)

Although all strategies used to promote dynamic propositions, some Cmaps presented too many static propositions. Figure 5c shows a Cmap with 10 dynamic and 9 static propositions. The concept "bioethics" has 5 static propositions, confirming the descriptive approach chosen by the author.

- bioethics - is an interface between - science (S)
- bioethics - is an interface between - society (S)
- bioethics - is regulated by - society (S)
- bioethics - is the ethics of - life (S)
- bioethics - is an attempt of -humanization (S)

4 Summary

Propositions are essential to understand the meanings from the Cmap networks. They can be thoroughly analyzed to find distinct differences [1] according to the verb used in the linking phrase (static and dynamic), [2] considering the potential cause-effect relationship between initial and final concepts (causative and non-causative), and [3] checking if the concepts are quantified (implicit, partially explicit, and totally explicit. These 3 aspects were the basis to create the proposed taxonomic scheme for classifying propositions presented in this work. Preliminary data from a set of 55 Cmaps confirmed the possibility of identifying patterns, which can be related to the authors' understanding about the subject and to their familiarity with concept mapping. Despite this work being explored Cmaps about science teaching, we believe that the taxonomic scheme for propositional analysis has a wide range of applications, including both educational and corporative uses.

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BEYOND INDIVIDUAL CLASSROOMS: HOW VALID ARE CONCEPT MAPS FOR LARGE SCALE ASSESSMENT?

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Abstract. Reliability and validity are still important issues for considering the use of concept maps as assessment tools. The presence of different concept mapping formats/techniques, different forms of traditional testing methods, and a plethora of concept map scoring systems, add complexity to the act of linking student concept map scores to meaningful learning outcomes. The present study provides a descriptive analysis of recent research on the reported concurrent validity of concept map assessments in the K-16 science classroom with more traditional assessment measures. Findings suggest that various fill-in-the-map techniques correlated well with standardized assessments for all learners. In addition, evaluator training for cncept map assessment, and a tight match of content used for both conventional test and concept maps, appeared to have a positive effect on concurrent validity. The results suggest that in addition to the use of fill-in-the-map formats for large scale assessment in science education, a combination of both techniques select-and-fill-in and create-a-map techniques must be used in concert as formative and summative assessment tools, providing complementary information about the content and quality of student learning in science.

1 Introduction

Even after 40 years of use in science education there remains an ambiguity among researchers as to the power of concept mapping as an assessment tool, with little attention paid to the reliability and validity of variations in concept mapping techniques."Before concept maps are used for assessment and before map scores are reported to teachers, students, the public, and policy makers, research needs to provide reliability and validity information on the effect of different mapping techniques" (Ruiz-Primo & Shavelson, 1996, p. 569). Since this statement was published, scant empirical data has been reported supporting reliability and validity of concept maps as assessment tools. This leads to our question: Based on the extant literature, to what degree and under what specific conditions if any do concept maps correlate with summative measures of learning in science education? This paper provides a descriptive analysis of recent research on factors associated with the concurrent validity of concept maps used as outcome assessment tools in the K-16 science classroom. Specifically, this review illuminates challenges in applying consistent and reliable scoring methods to the various concept mapping tasks, highlights the variability in types of information about the learner gained using different types of concept mapping tasks, and emphasizes the need to align the content and processes measured by both concept maps and alternate assessments in order to making inferences about concept maps as valid, reliable measures of science learning.

2 Background

2.1 Scoring Concept Maps for Conceptual Understanding: Issues of Reliability

2.1.1 Assessment of expert knowledge in science

The current emphasis on contextual forms of assessment in science education provides a platform for concept mapping to move beyond assessing learning in individual classrooms and into the broader arena of large-scale assessment. However, a survey of the literature suggests that there are certain logistical and scoring reliability considerations that need to be addressed before the concept mapping community can move forward (Ruiz-Primo & Shavelson, 1996). This is not to say that large-scale assessment using concept mapping have not been previously attempted. Some existing research, including the authors' previous work, provides evidence for large-scale concept mapping, within certain given constraints of evaluator training, and similarity of instructional strategies and requirements. Even though

concept maps are able to demonstrate robust learning effects both for instruction and assessment, the main issues with using concept maps for large-scale assessment are the problems of maintaining content and scoring reliability across the board (Ruiz-Primo, Schultz, Li, & Shavelson, 2001).

An important aspect of contextual learning in science education is helping students assimilate Problem Based Learning techniques by combining the ability to think creatively (to generate ideas) and apply critical thinking (to evaluate ideas). Both modes of thinking are essential for a well-rounded understanding and application of science content. Content and a contextual framework are both important in order to evaluate the generation and ability to evaluate ideas. In this context, the ability to think about thinking as visualized by a concept map then becomes a powerful means of procuring students' understanding. Applied to science education, content and context refer to domain-specific knowledge and true-to-life application of this knowledge, respectively. Although disciplinary knowledge (content) is readily procurable (through a variety of sources), consensus by experts as to the ordinate and sub-ordinate features of such knowledge for teaching purposes is hard to come by. Maps by individual experts and instructors can be highly variable in both the generalities and specifics of the map. In addition, differences in instructional strategies and classroom requirements impact and influence what is learned and how it is learnt (context of learning). These factors in turn impact the degree of concept understanding for learners in the classroom and can result in reliability issues when scoring concept maps (Hollenbeck, Twyman & Tindal, 2006; Rice, Ryan & Samson,1998).

2.1.2 Variations in concept map scoring systems

Different scoring techniques measure different aspects of conceptual organization and/or understanding. Some of the scoring systems are based on scoring the accuracy and position of propositions while others are comparisons to a criterion map (Ruiz -Primo, Schultz, Li,&Shavelson, 2001). A large variety of scoring systems exist that add to the complexity of reliability, with some researchers in favor of not scoring maps to others designing elaborate computer-based scoring systems (Rice, Ryan,&Samson, 1998; Ruiz-Primo et al., 2001) Current research suggests that estimates of the reliability of scores are affected by the nature of the task, and the scoring scheme that make up the concept-map assessment. The more directed the task the easier the assessment is to grade and thus reliability and task directedness increase proportionally (Debrentseva et al., 2007; Hoeft, Jentsch, Harper, Evans, Bowers, & Salas, 2003; Kaya & Kilic, 2004; Ruiz-Primo et al., 2001; Schmidt, 2006; Shavelson et al., 2008).

The selection of concepts used in the mapping task can likewise impact both the restrictiveness and demands placed on the student. For example, a list of concepts that are highly related will pose different demands and constraints on student responses than a list of loosely associated concepts. One way to capture student knowledge structure without considering the spatial layout of the map is to consider two propositional attributes proposition choice/importance and proposition accuracy. If students are to pair concepts that have hierarchical relationships, then this would be a criterion for appropriate proposition choice. If the essential relationship between the two concepts is hierarchical in nature, then students would be expected to express a hierarchical relationship in the linking phrase in order for the proposition to be considered accurate.

Few studies prior to 1995 accounted for the reliability of mapping scores, instead, most studies reported inter-rater agreement (Ruiz-Primo et al., 1996). Not much has changed since their review of assessment literature with few studies considering other sources of measurement error such as, equivalence of test forms (Ruiz-Primo et al., 2001), internal consistency (Yin & Shavelson, 2005), score stability across test occasion, (Yin & Shavelson, 2005), and such as the consistency of student rankings between raters (e.g., McClure et al., 1999). Very few studies then have compared the reliability estimates of different scoring systems. Much of the work on the reliability estimates of scoring have involved comparison of two different or similar mapping formats, such as comparison of open-ended map construction with fill-in-the-map format (Ruiz-Primo et al., 2001) or comparison of two type of fill-in the map formats (Yin & Shavelson, 2005). McClure and colleagues (1999) reported a significant piece of research comparing six different types of scoring methods. Six pairs of independent raters used one of the following scoring methods: (a) holistic, (b) holistic with master map, (c) relational, (d) relational with master map, (e) structural, and (f) structural with master map. The holistic method involved rating student overall understanding on a scale from 1 to 10. The relational method used a three point scale to measure the accuracy of each proposition used by the student. Reliability coefficients for the six methods ranged from .23 to .76. The lowest correlations were reported from the structural scoring method using a master map for comparison and the highest correlations were reported by raters applying the relational scoring method

using a master map for comparison. According to the researchers some factors that might have served as sources of assessment error could include: (a) variations in assessor content knowledge/expertise, (b) differences in students' ability to follow concept-mapping conventions, and (c) the consistency of concept map evaluation (McClure et al., 1999). This last factor is largely dependent on the scoring method. In order to reach reliability of scoring among different scoring systems raters need to be able to balance content with the purpose of the assessment.

2.2 Variations in Concept Map Task Demands: Issues of Validity

2.1.2.1 Assessment of rote vs. procedural knowledge

The type of knowledge that is measured by traditional versus alternative assessment tools (concept map) adds to the complexity of using concept maps for assessment: to what extent do concept map assessments actually measure what students understand, or do they over- or under-estimate student understanding? Traditional assessment methods such as Standardized Tests usually examine a mix of rote learning and some procedural knowledge (citation for this?). Concept maps on the other hand, capture knowledge structure at any given point in a learner's trajectory and lay a greater emphasis on process in order to measure deeper understanding (Novak 1990; Novak & Gowin, 1984). Concept mapping assessments are described in the literature as having the potential to differentiate between learning due to rote memorization versus knowledge that is integrated to pre- and new conceptions. The best way to do this would be to assess student understanding using concept maps along a timeline at different points during the semester when rote learning has been forgotten. The lack of standardization of scoring methods among concept mappers and time constraints impacting classroom training, implementation, and assessment is perhaps why this very fundamental factor has not yet been tested to any great degree.

2.1.2.1.2 Differences in the level of student generativity among concept mapping tasks

The task demands inherent in the act of concept map creation, which greatly vary in level learner generativity, number and type of constraints, also need to be explored as potential factors influencing the potential for concept map scores to represent meaningful learning outcomes. The structure of the map, concepts, linking lines, and linking words may be provided within the task or may be learner-generated, with greater generativity by learner increasing the level of task demand. In addition, irrespective of concept map structure, the specific content of the concepts or linking words provided for learners to arrange or "fill in" can place both restrictive constraints and topic-related demands on the student. For example, a concept list that is loosely connected presents a different set of cognitive demands on a student than a tightly connected list of concepts. Consideration of two propositional attributes, proposition choice/importance and accuracy functions are important. Students' choice of hierarchical linking words between hierarchical concept pairs would demonstrate accurate understanding of the hierarchical nature of concept pairs (Schau et al., 2001). Finally, the wording of the question stem has the potential to impact the content and structure of the concept map. Derbentseva and colleagues (2007) report that most maps answer a question of, "what is…X?" which necessitates a description of concept X (for example, identifying component parts, specifying categories, specifying uses or functions). Other questions, such as "what happens when X changes" or "how does X work" requires the learner to think about how the concepts affect each other, eliciting more dynamic linking terms and cyclical map structures.

A review of the current literature indicates that there are multiple ways that concept maps have been used for assessing student learning in the science classroom, varying in both conceptual and structural generativity required by the student. Researchers in the K-16 environments have reported the use of task structures primarily falling into the following three main categories: (i) Create/Construct-a-map technique, (ii) Fill-in-a-map technique, and (iii) Create-a-map technique with either links created by student (C-mapping) or links (S-mapping) provided based on specific criterion (provide citation/s).

The "Create-a-map" technique (C-mapping) involves creating a concept map with unique structure and linking phrases based on concepts and terms that are common to a particular topic. There are several ways in which this can be achieved. One way, especially with young and novice learners, is to provide a 'parking lot' of concepts associated with a particular topic, much in the same manner as a vocabulary list provided in standards based lessons. The students use this concept list to generate a map using linking words and cross-links based on their individual or group understanding of the topic. Another method used in creating-a-map, especially with older and experienced learners is to simply rely on the individual's own knowledge regarding a particular topic and using that knowledge to create a map either

by themselves or by an interviewer translating the individual's ideas into a concept map. The use of unique linking words and cross-links used to create-a-concept map by either of these methods provides an insight into the individual's or groups' understanding of a related set of concepts at a given time. Depending on the nature of the task, this could be a holistic or a specific narrow topic. Although this type of open-ended map construction reveals preconceptions and misconceptions, and a picture of the students' knowledge structure, it is difficult to score unless compared tightly to an expert map following specific parameters. The main problem with scoring open-ended maps is the plethora of possibilities based on proposition number, proposition choice, and structure of concept relatedness that are possible due to individual understandings. This makes it difficult to score the maps and also creates reliability issues especially when compared to traditional assessments (Yin et al., 2005).

"Fill-in-a-map" formats use an expert-drawn concept map structure and either omit some concepts or some linking words. Students can fill-in these maps either by generating the words or by selecting from a provided list, a technique referred to as "Select-and-fill-in" (SAFI) (Schau et al., 1997; Schau, 2001). Each of the fill-in items can be a part of one or several inter-connected propositions. Depending on the type of format used, students can either choose a node term or link term both of which add to the visualization of specific domain knowledge. Although fill-in-the-map formats can correlate robustly to traditional assessments such as standardized tests and instruction-directed multiple choice tests, they are constrained by providing the students with the domain structure being assessed (Schau, 2001). This means that fill-in-the-maps might not represent students' individual understanding nor the connectedness of understanding for the domain of knowledge (Schau, 2001). The advantage to fill-in-the-map technique lies in its ability to differentiate between rote learning and conceptual learning, since rote learning is readily forgotten and conceptual understanding (even superficially) is required for connecting propositions. A more pertinent advantage of fill-in-the-map techniques is the reliability with which they can be scored when compared to the expert map.

The third technique, "C- and S-mapping" technique uses the create-a-map technique with either the concepts or linking words prescribed (Yin et al., 2005). Although this sounds similar to the constructing a map from a 'parking lot' of concepts, it is different because the prescribed concepts or linking words are based on a pre-set expert or criterion map. Both C- and S-mapping techniques use reliable scoring methods based on the criterion provided and can be easily adapted to an electronic format. The main disadvantage to these two methods lies in the inability to differentiate scores from a high and low performer (Yin et al., 2005). Unless the quality of propositions? are specified in a C-mapping technique, in addition to quantity, two individuals can receive the same score, one using concise propositions and the other using imprecise or superficial propositions (essentially guessing) that both result in accurate content. Examination of the concept map based on the use of key propositions and the quality of propositions used, in addition to number, would differentiate high performers from low performers. With respect to the S-mapping technique, student language skills can positively or negatively aspect use of linking words and only partially reflect individual understanding. Yin and colleagues (2005), suggest that in designing C- and/or S-mapping formats, expert criterion must consider student language skills, student vocabulary, and student misconceptions in order to provide valid measures of knowledge.

As these examples illustrate, while concept map performance scores may reflect deep, conceptual knowledge, they also are likely to represent the facility to which a student is able to engage in task-specific cognitive processes, such as organization and integration of information, comprehension monitoring, planning next steps, reflecting about conceptual relationships, and expressing knowledge. Identifying the cognitive processes inherent in various concept maps have important implications for establishing reliability and validity. First, in order to make an accurate correlation between concept map scores and scores to alternate measures, the level of generativity on the concept map needs to match that which is required in the alternate assessment. Second, the more directed a task, such as in fill-in-a-map formats, the easier it is to specify a scoring system and thus increase the reliability of the concept mapping assessment process.

The main purpose of the present study was to synthesize the current literature reporting the use of concept maps for assessment in the K-16 science arena, specifically investigating the extent to which concept maps are reported as valid measures of student learning when compared to traditional assessment measures. Specifically, we conducted a review of studies reporting the correlation between scores from student generated concept maps and other measures of achievement (concurrent validity), taking into account both the type of concept map assessment, the type of scoring system, and the match between the two.

3 Method

A review of articles including populations ranging from elementary to post-secondary was conducted. A thorough database search, carried out within PsycInfo, ISI, ERIC, and Google Scholar was implemented to locate all potential articles for review, using the following search criteria:
Topic=("concept map*" OR "knowledge map*" OR "mind map*") AND Topic=(validity OR validate) AND Topic=(science OR scient*).

Articles were selected for review which reported concept mapping tasks used for the purposes of providing information about student knowledge / conceptual understanding in science, and alternate assessments were given concurrently to the concept mapping task. The 25 studies selected ranged from elementary classrooms, middle school and secondary environments, through pre-service teacher preparation to medical school classrooms.

Current research on the use of concept maps for assessment in science education was coded using the ten criteria shown in Table 1.

Population	Sample Size	Prior-experience	Ability Level	Topic	Assessment Timing	Type of Cmap	Alternate Assessment	Scoring Method	Reliability

Table 1. Criteria used for coding research on concept maps as assessment tools

The coding allowed for a comparison of different concept mapping techniques used, denoted by type of concept map, to robustness – high or low to alternate assessment measures. This provided a measure for reliability of concept map techniques to traditional methods of assessment. Some examples are provided in Table 2.

Cmap Technique/Source	Alternate Assessment	Robustness of Correlation
1.Create-a-map from scratch /Kaya & Kilic, 2004	Standardized Test	Low (r = .478)
2.Fill-in-a-map/Schau et al., 1997	Multiple Choice Test	High (r = .75)
3.Create-a-map: C- and/or S-mapping/Yin et al., 2005	Instructor Designed Test	Modearate (r = .5 or .6) r value depends on C- or S-type

Table 2. Robustness of concept map techniques to alternate assessment measures

Those studies that showed a moderate to high measure of correlation between concept maps and alternate assessments were further investigated for logistical components such as: (i) study design, (ii) training of assessors, (iii) ability level of learners, (iv) similarity of instructional strategies between classrooms, and (v) cmap scoring method (McClure et al., 1999). Among others, these five factors can have an integral impact on measurement of classroom learning and are critical to the implementation of concept mapping in large scale assessment. Table 3 shows further analysis of example 3, used in Table 2.

Yin et al., 2005	Study Design	Assessor Training	Learner Ability Level	Similarity of Instruction	Cmap Scoring Method
Create-a-map	Robust – based on field testing	Advanced	Average-High	Controlled – single instructor in all 6 classes	Looked at propositions with respect to expert designed criterion

Table 3. Example of factors that impact use of cmaps in classroom assessment

4 Analysis

Table 4 summarizes the findings for this analysis with respect to concept map technique used to measure student understanding using the 25 selected studies and the degree of reliability based on correlations with alternate assessments. The range of correlations reported in these studies with respect to multiple choice assessments were moderate to high ranging from .475 to .80, with fill-in-the-map techniques being highly correlated to traditional assessment formats

such as multiple choice tests, short answer essays, and achievement tests (Ahlberg & Ahronta, 2008; Henno & Reiska, 2008; Hollenbech et al., 2006; Ingec, 2009; Klein et al., 2002; McClure et al., 1999; Schau et al., 1997; Schau et al., 2001; Yin et al., 2005).

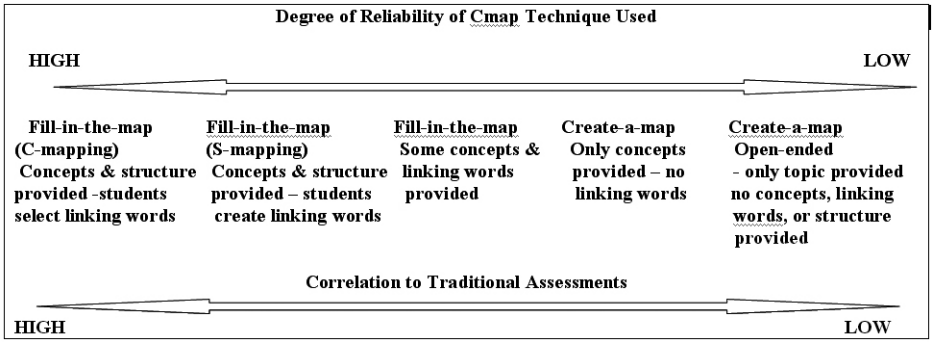


Table 4. Correlation of concept map techniques to traditional assessments as a measure of reliability

The correlations of multiple choice test and other conventional tests with create-a-map from scratch reported a range of reliability measures from low (r = .41) to high (r = .77) (Hollenbeck et al., 2006; Schau et al., 1997). The match of content being tested to content used to generate the concept maps appeared to greatly influence the summative analysis in these studies. For example, the Hollenbeck (2006) study reported a low correlation between student-generated concept maps and problem solving essays. The study suggested that there was a low rate of exchangeability between information on student maps and student essays. Although some of this result could be due to small sample size, and sample selection, other studies also reported low correlations between student-generated maps and multiple choice tests (Ingec, 2009; Liu & Henchley, 19961a). In all these cases, the low correlation actually provides validity for the concept mapping measure since there was either a disconnect between the material being tested or it was seen as a content/topic dependent effect i.e. force and solutions (Liu & Henchley, 19961a). By the same token, the stronger correlations are indicative of tighter matches between material used for the tests and the concept maps (Heno & Reiska, 2008; Rice et al., 1998). With respect to fill-in-the-map techniques, the more constrained the map structure, the higher was the reliability correlating to multiple choice tests, r = .74-.77 (Schau et al., 1997). For the SAFI method of mapping, the student map scores were appreciable when compared to multiple choice test scores (r = .61-.83), (Schau et al., 2001). The range of scores observed fell within reported correlation estimates for comparison of concept maps and multiple choice scores. Studies using the SAFI technique suggests that while the C-mapping technique is better for capturing student partial knowledge, the S-mapping technique is easier to score (Yin et al, 2005, Yin & Shavelson, 2008). In addition, a recent report by Shavelson and colleagues (2008) lends validity to using the fill-in-the map technique for formative assessment especially when embedded in the curriculum.

5 Conclusion

Our analysis suggests that "fill-in maps" were the most highly correlated with other, more traditional assessment measures. As an additional advantage, the "fill-in" task format lends itself to a reliable method of scoring for large scale assessments, when compared to open-ended maps constructed from scratch. Three aspects of the "fill-in maps" likely contribute to their scoring reliability: First, the task constraints are communicated through a clear quantification of concepts used and clear task expectations, ensuring that specific forms of knowledge are tapped (Debrentseva et al., 2007). Second,"fill-in maps" can be scored objectively according to an expert or criterion-referenced key (McClure et al., 1999). Third, "fill-in maps" can be easily matched to complement the content and process knowledge covered included within conventional tests.

However, while concurrent validity to the content of traditional exams is gained, perhaps some information regarding other forms of student knowledge is lost; by their nature, "fill in maps" are not designed to detect misconceptions or depict a student's unique structure of knowledge. Depending on the scope of the assessment, "fill-in maps" may not provide the potential for the student to make links to a larger conceptual framework within the science domain, to other academic domains, or to personal experience.

Based on our review, we propose that a combined method using a series of select-and-fill-in-the map (SAFI) technique as formative assessment together with create-a-map technique for summative assessments might be best for large scale assessment. This would require front-end preparation using electronic formats for ease of scoring but can be easily setup using available technology (Chang, Sung, Chang & Lin, 2005; Hoeft et al., 2003; Taricani & Clariana, 2006; Ruiz-Primo et al., 2001; Yin & Shavelson, 2005). The development of a scaffolded trajectory consisting of teacher training and professional development for formative and summative assessment, and designing assessment embedded in curriculum is critical to avoid disconnect and student confusion when tested by traditional and alternate methods of assessment (Ayala et al., 2008; McClure et al., 1999; Shau et al., 1997; Shavelson et al, 2008).

In order to address a timeline of reliable progression, i.e. to be able to differentiate between rote learning and conceptual understanding, it is necessary to measure formatively using fill-in-the-map techniques, where fill-in-the-links is more robust measure of student knowledge than fill-in-the concept technique (Ruiz-Primo, both 2001s; Schau et al.,, 1997), and then use a construct-a-map technique at major intervals to correlate with and supplement the information provided by the formative fill-in-the-map technique. (Shavelson et al., 2008). This approach would address both the reliability and validity of using concept maps as assessment of and for learning.

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COLLABORATIVE BUILDING OF SOCIOCULTURAL AND CONCEPT MAPPING THEORIES

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Abstract. The power of concept maps can be seen in their ability to represent the complexity of knowledge and understanding at a number of levels including the theoretical and the practical. This paper recounts the collaboration in practical applications that lead to theory building between two scholars, Holbrook Mahn, whose main research interest is sociocultural theory, and particularly the work of the Russian psychologist, Lev Vygotsky, and Manuel F. Aguilar Tamayo, whose main research interests include concept maps and sociocultural theory. We collaborated together on several projects using Vygotsky's, Novak's and Ausubel's work as a theoretical foundation. Through these applications, we gained a deeper understanding of each other's main research interests at the same time deepening our understanding of the theory that is a primary focus of our own research. After describing our collaborative activities, we describe ways in which Vygotsky's theory and Concept Mapping Theory can lead to a deepening understanding and representation of the other. In the course of the collaboration, we saw the areas of similarity and dis-similarity between the two theories and are now collaborating on a chapter for a book on concept maps in which we will compare the two theories and describe ways in which each theory complements and can expands the other. In the Discussion section at the end of this article we give an overview of ways in which we feel Vygotsky's theoretical framework, methodological approach, and research, which led to his analysis of the origins and nature of concepts, can help in building a solid theoretical explanation of the concept concept.

1 Introduction

Sociocultural approaches are increasingly being used in a variety of different disciplines to study the role that language and culture play in the development of many distinct human activities. Similarly, approaches using concept maps have been used successfully to represent knowledge in these same activities, from education to business, from social and natural sciences, and from empirical research to applications with social and artificial intelligence. Both approaches emphasize the importance of social interaction and collaboration in the development and representation of conceptual knowledge and understanding. We first engaged with each other on a theoretical plane, but quickly began to collaborate on different types of projects together. These efforts have led us to propose a way in which sociocultural theory can make a substantial contribution to the theoretical framework of concept mapping theory. Vygotsky's work, which provides the theoretical framework for sociocultural theory, focuses on the development of concept formation resulting from the interrelationship between thinking processes and those involved with language acquisition and use. His analysis of concept formation as a key to the development of human psyche and consciousness involves looking at the way in which humans create a system of meaning through language use. We argue that Vygotsky's analysis provides an expanded theoretical foundation for concept mapping.

2 The Collaboration

2.1 Theoretical Framework

Vera John-Steiner (2000) in Creative Collaboration writes: "Generative ideas emerge from joint thinking, from significant conversations, and from sustained, shared struggles to achieve insights by partners in thought" (p. 3). John-Steiner studies the processes of collaboration and creativity by partners, groups, and communities in different disciplines in science and the arts. In explaining her theoretical framework, she writes, "I rely on L. S. Vygotsky's cultural-historical ideas that creative activities are social, that thinking is not confined to the individual brain/mind, and that construction of knowledge is embedded in the cultural and historical milieu in which it arises" (p. 5).

Our collaborative process is described in two dimensions in this paper. The first is in a narrative mode, which explains the scenarios, interactions, and the genesis of new perspectives on teaching and learning, in this case, based on Vygotsky's theory. The other dimension, which is more analytical, more logical-abstract than the narrative, presents the process of understanding concept mapping from a Vygotskian perspective, within the collaborative process in which concept maps are used. Concept maps and Vygotsky's theory are used as theoretical complements, with the teaching/learning process organized using Vygotsky's theory. While concept maps are used as tools for mediating communication and learning, they also introduce a new element to the Vygotskian theoretical framework. The narration of our collaboration reflects the dialectical process for understanding and for theoretical discussion as well as reflecting our practice in teaching, learning, and research.

2.2 First Encounters

We first met when Aguilar Tamayo was visiting the University of New Mexico. On hearing of Aguilar Tamayo's interest in sociocultural theory and particularly Vygotsky's work, Mahn gave him an article he had written for Educational Psychologist on Vygotsky and sociocultural theory. The next day Aguilar Tamayo showed his concept map of the article to Mahn, who was so impressed with the way that the concept map represented the essence of the ideas in the article, that drawing from Casablanca he said, "Manuel, I think that this is the beginning of a beautiful friendship." He then invited Aguilar Tamayo to attend a doctoral-level seminar, he was teaching, to plan a course to prepare teachers for teaching linguistically and culturally diverse students.

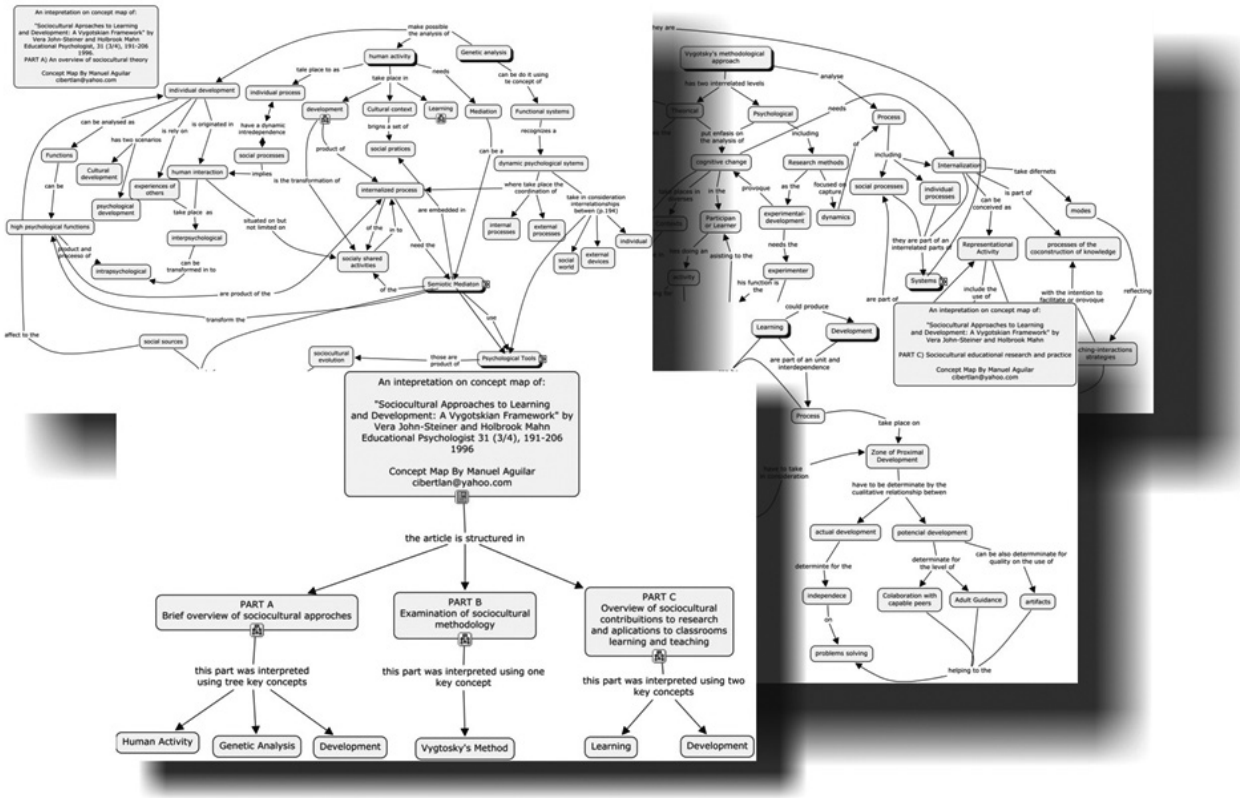


Figure 1. The analysis using a concept map of Mahn's article was presented as a knowledge model. The concept map at the front explains the concepts used for the analysis and links to the three concepts maps making it possible to navigate through them and access the article.

2.3 Facilitating Learning in a Planning Seminar

The rationale for that course was that while increasing multilingual, multicultural, and multiethnic diversity is reflected in US classrooms, teachers have generally not had the education to effectively respond to the needs of their linguistically and culturally diverse students. In order for educators to value and draw on the linguistic and cultural resources that students bring to the learning context, they need to better understand their students. Understanding the larger sociopolitical contexts of education, the nature of diversity, the way in which language and culture shape students, and the ways in which they learn, helps teachers fashion education that not only helps linguistically and culturally diverse students but all students. Therefore, the planning seminar looked at cultural diversity, second language acquisition processes and programs, curriculum and pedagogy, and ways to empower students by drawing on their strengths and their lived experiences and developing their confidence in their abilities to learn.

The theoretical foundation for the seminar was provided by the work of Vygotsky. One of the challenges in the workshop was tying this framework to pedagogy and then providing coherence to a proposed curriculum. Using concept maps, Aguilar Tamayo helped the seminar integrate theory and practice.

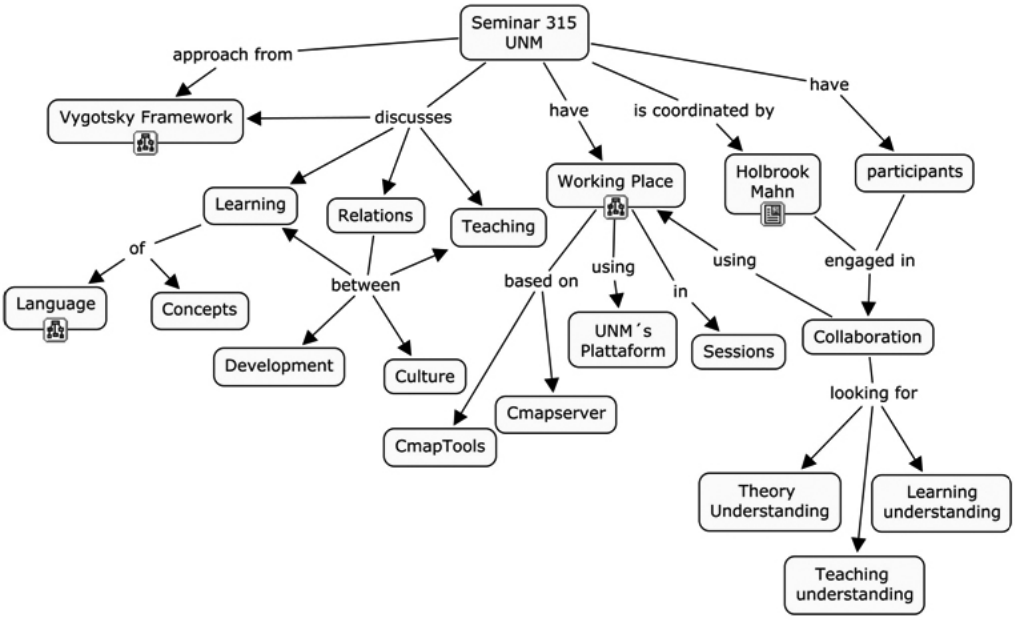


Figure 2. The concept map of the doctoral planning seminar

2.4 Preparations for Conference Presentations

Following their collaboration in the planning seminar, Mahn and Aguilar Tamayo collaborated in the preparation of presentations for both the 2005 and the 2008 International Society for Cultural and Activity Research (ISCAR) conferences in Seville, Spain and San Diego, CA. The diagrammatic representation of concepts that Mahn learned from Aguilar Tamayo helped him design a diagram that was at the center of his analysis of Vygotsky's concepts of System of Meaning and Concept Formation. This diagram and the concepts it describes are detailed in Mahn (2008).

In organizing their presentations, Mahn and Aguilar Tamayo discussed the relationship between Vygotsky's theory of concept formation and representation through concept maps, drawing on the respective research communities. Aguilar Tamayo discovered the interest of the ISCAR community in the uses of concept mapping, but at the same time saw the community's limited understanding of the implications for pedagogy and research on the learning of concepts represented in the use of concept maps. They were perceived as an incidental technique in the field of education, despite the possibilities for concept maps transforming educational practice (Novak & Cañas, 2004) and

educational research (Novak & Gowin, 1984). Because Aguilar Tamayo thought how this perspective could be related to the Vygotskian theoretical perspective, he started working on the deconstruction and reconstruction of the concept map, (2004, 2006). The concept map as an external representational system could now be subjected to interpretation and questioning from a different theoretical perspective.

In his presentations on the use of concept maps Aguilar Tamayo incorporated aspects of Vygotsky's theory (Aguilar Tamayo, 2008) and also presented a paper on concept maps and Vygotsky's ideas at the 2006 Second International Conference on Concept Mapping (Aguilar Tamayo, 2006), which is described below in the Discussion section. Aguilar Tamayo and Mahn also began to consider another important issue, the concept of concept, from Mahn's (2005, 2008) interpretation of Vygotsky's work on the genesis, the structure, and the function of the concept. In this process Vygotsky's theory became more explicit for Aguilar Tamayo, helping him gain new insights into Novak's and Musonda's article (1991) where the process of the construction and development of conceptual understanding are explained. These insights made explicit the need for building more bridges between Vygotsky's and Novak's perspectives on concept formation and learning.

Aguilar Tamayo and Mahn were able to work on building these bridges through their preparation and implementation of a workshop on Vygotsky. A central aspect of planning this workshop was discussion of Vygotsky's notion of the system of meaning and it relationship to the system of concepts, including the relationship between academic/scientific concepts and everyday concepts. In the course of the workshop planning, a number of questions were raised. What does a concept map represent? When is it intended to represent the domain of knowledge? Is it capturing the students' uses of scientific concepts? How is the emotional aspect of learning part of the learning of concepts in school? What are the misconceptions related to everyday concepts? If a student's previous knowledge or prior understanding is to be considered for teaching in order to provoke meaningful learning, what is the relationship between their use of everyday concepts and academic concepts? Many of these questions have been addressed in constructivist and/or cognitive perspectives; however, Vygotsky's analysis afforded Aguilar Tamayo and Mahn new ways to understand research findings and to explore different interpretations. The next step was to test these theoretical perspectives in the learning and teaching in the workshop on Vygotsky.

2.5 Workshop on Vygotsky Using Concept Maps

Aguilar Tamayo and Mahn collaborated on this workshop on Vygotsky's theory held at Aguilar Tamayo's university in Mexico. The workshop planning concept map provides an overview of the workshop.

2.5.1 Academic Literacy for All Protocol and Concept Maps

A central activity that Mahn and Aguilar Tamayo used in the workshop was based on a project directed by Mahn in the United States designed to help secondary teachers understand how they can facilitate the language and literacy development of their English language learners (ELLs) at the same time that they are teaching the content concepts. To help with this professional development effort, Mahn created a protocol based on Vygotsky's work on conceptual thinking in which students, who are organized in groups of four, write two sentences based on a prompt, about which every student should be able write two sentences and one that encourages students to draw on their prior knowledge. Then students in pairs create two new sentences drawing on the concepts from each partner's sentences and then in groups of four create two more sentences. These are written on poster paper and displayed at the front of the class. The students all analyze them and decide which one, other than their own group, best represents the concept. They then analyze the groups' sentences looking for common themes and vocabulary. Finally, they look at words that are logical connectors, such as "because" "if…then" which hold the key to understanding the concepts represented in the sentences (Figure 3). (Details can be found at http://ala.unm.edu/).

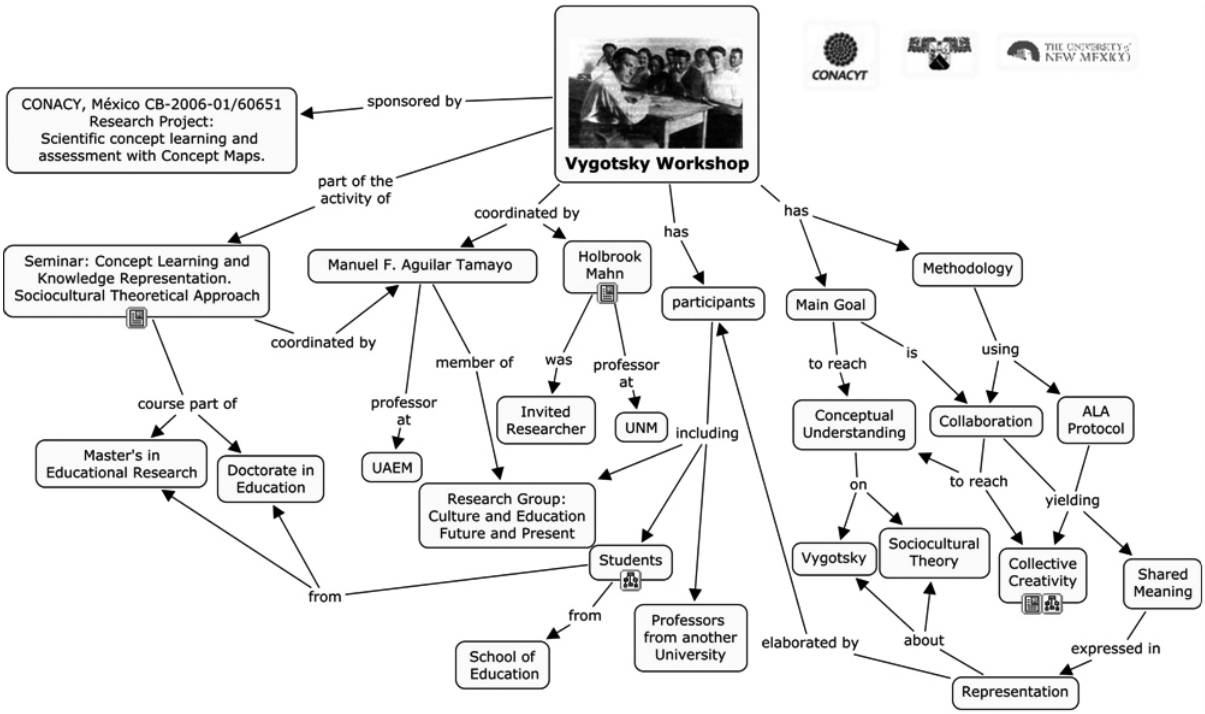


Figure 3. Here we describe an activity used in the workshop that shows the theoretical and practical relationship between sociocultural theory and concept mapping theory.

During the Vygotsky workshop the concept of generalization was presented as the prompt for the protocol. As one of the participants stated, "the discussion generated from the review of the sentences from each of the groups enriched the knowledge of the individual's and the group's concept, and it provided new important concepts about generalization." After doing the protocol, the workshop participants worked in groups for initial discussions on the development of the structure of generalization that is at the center of Vygotsky's work on concept formation.

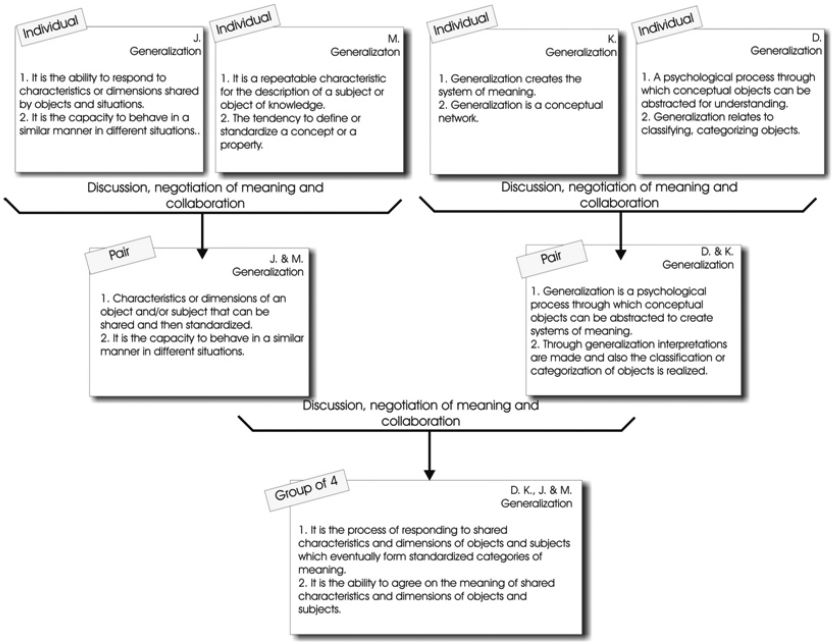


Figure 4. The ALA protocol process, in which the production of text is related to individual writing, collaboration in pairs, and then pairs of pairs, which produced the group's final text. Note the sense of each new text, in which key concepts, are integrated more generally or abstractly.

Mahn has used concept maps with the teachers in the ALA project to help them develop a better understanding of the concepts that they are teaching. The processes involved in the protocol can be compared to those used in constructing a concept map: "Propositions are statements about some object or event in the universe, either naturally occurring or constructed. Propositions contain two or more concepts connected using linking words or phrases to form a meaningful statement" (Novak and Cañas, 2008, p.1, italics in original). The ALA Protocol helps students formulate propositions and then with partners discuss their propositions in order to create a new one. This involves negotiating between participants, discussing the sense of their propositions, and then deciding which specific concepts to include or exclude, similar to the process of elaboration in creating a collective concept map.

In the Vygotsky workshop four groups of four students were involved in the protocol activity. Figure 3 represents the text creation process for one group. Each new text was discussed, negotiated, and created in collaboration between pairs and then pairs of pairs, resulting in a group text. The appropriation of the new text was a product of collaborative discussion; the final text represents the synthesis and consensus of the participants' thinking. This discussion and negotiation process was recorded and followed using a Livescribe pen (www.livescribe.com), which captured the collaboration process and the production of text. For instance, if we follow J's initial writing in Figure 3, and then the collaboration in a pair, J&M, producing the new text (recorded including the writing synchronized with voices), then it is possible to follow J&M's collaboration with D&K in the final discussion between all 4 participants.

The discussion and the texts produced allow for a wider interpretation of the final text, beyond just the inclusion or exclusion of concepts and the negotiation of the meaning. The participants frequently expressed what they understood for one term and in this process, they learned new terms and were able to clarify the meaning. The new texts also reflected changes in writing style, as they expressed a shared meaning, which included all ideas, resulting in a more complex construction, without exceeding the two-sentence limit.

Students also reflected an emotional aspect in their discussions. For example, students defended their opinions, in personal ways, such as a student, in the discussion between pairs, said: "…yes, I am more of a global thinker. I like to think taking into consideration more aspects…" For every collaboratively written text, students assumed authorship: "Our definition includes cultural and social aspects…" Personal satisfaction reflects an interested and willing participation: "My personal experience was at the beginning of the activity, easy; however, when we start working in pairs and putting our ideas on the table, it turned out to not be so easy. It becomes more complicated when we started working in groups of four and we put our diverse perspectives into the discussion, trying to get something in common and in the end, we did it!"

2.6 Future Research and Theory Building

With its analysis of the relationship between the individual and the social and how it relates to learning and development, Vygotsky's theory provides a substantial foundation for examining group learning with concept maps. Daley, et al (2008) have argued that concept mapping theory should investigate the use of concept maps as a means to engender group learning. "Studies have shown that shared mental models can develop through collaborative learning and from the interaction of individuals in the development of a group map" (p. 90). Group learning with concept maps in the Vygotsky workshop helped promote collaborative understanding of complex concepts. A participant reflected on this process: "The negotiation of meaning helped us move from awareness to understanding, and at the same time enabled and encouraged the development of higher mental processes, which encouraged reflection, discussion, cooperation, and enriched the formation of concepts, leading to more complexity and depth."

3 Discussion

3.1 Concept Maps and Vygotsky's Theory

As Aguilar Tamayo (2006) notes, Novak (2002, 2004) has acknowledged the importance of Vygotsky's best-known concept – the zone of proximal development. He also describes the importance that Novak ascribes to language as an important component of cognitive development. Similarly, both sociocultural theory and concept mapping theory focus on the impact that education has on children's learning and cognitive development. Aguilar Tamayo (2006) also

compares Vygotsky's emphasis on the importance of social interaction in child development and the fact that one of the design principals of Cmap Tools is cooperation and shared knowledge (Novak and Cañas, 2004).

In an article giving an overview of the theory underlying concept maps, Novak and Cañas (2008) describe the interrelationships between the key memory systems that create a unified whole. The interrelationships among mental functions as a determining factor in the nature of the human psyche was also fundamental to Vygotsky's approach. They describe a fundamental idea in Ausubel's cognitive psychology "that learning takes place by the assimilation of new concepts and propositions into existing concept and propositional frameworks held by the learner. This knowledge structure as held by a learner is also referred to as the individual's cognitive structure" (p. 3). While there are differences, this resonates with Vygotsky's (1987) theory of System of Meaning, which examines the development of an internal mental system through language development and concept formation (Mahn, 2008).

3.2 Differences Between Concept Mapping Theory and Vygotsky's

Aguilar Tamayo (2006) details how Vygotsky (1987, p. 126) in sociocultural theory and Novak (1998, p. 58) and Ausubel (2002, p. 31) in concept mapping theory see the relationship between word and concept as primary. However, a fundamental difference between the two theories is the way that they define and analyze concepts. For concept mapping theory, Cañas and Novak (2009), drawing on the work of Novak, Ausubel, and Toulmin, define "concept" as "a perceived regularity or pattern in events or objects, or records of events or objects, designated by a label" (p. 1). Vygotsky described the key role that words, or labels, play in concept formation, but went beyond the perceived regularities or patterns which are aspects of the concept, to analyze the unification of the thinking and language processes that is the foundation upon which concepts are built. "A central and basic aspect of the structure of mental functions is the use of the sign as a means of directing and mastering mental processes. In the problem of interest to us, the problem of concept formation, this sign is the word. The word functions as the means for the formation of the concept. Later it becomes its symbol. Only the investigation of the functional use of the word and its development from one age to the next…provides the key to the formation of concepts" (1987, p. 126).

Vygotsky's major work, Thinking and Speech, details the ambitious research plan that he and his colleagues carried out investigating the development of the concept through an analysis of the development of the system of meaning with the structure of generalization as its foundation. Vygotsky's work on concept development can help expand the common definition used in concept mapping theory and the analysis of the origins of concepts used by concept mapping theory.

Drawing on McNamara, Cañas and Novak (2009) write, "The question sometimes arises as to the origin of our first concepts. These are acquired by children between birth and three years of age, when they recognize regularities in the world around them and begin to identify language labels or symbols for these regularities. ... This is a phenomenal ability that is part of the evolutionary heritage of all normal human beings" (p. 2). The question is how does this process unfold? What sort of development in the children's mental system is necessary for them to be able to recognize regularities? How do they begin to identify language labels or symbols – what is the relationship between language use and thinking processes? Questions Vygotsky addressed in his research, the results of which are presented in Thinking and Speech. His answers can provide an important enhancement to concept mapping theory by expanding the understanding of concept and revealing its origins and course of development. Unlike concept mapping theory, Vygotsky felt that when the child first acquired a word, the development of the concept had just begun. The main point of his research and theory building was "that the development of the corresponding concept is not completed but only beginning at the moment a new word is learned. The new word is not the culmination but the beginning of the development of a concept" (1987, p. 241). He focused on qualitative transformations in the development of the system of concepts during which a child's thinking processes undergo a profound change, so that children's use of concepts differs depending on where they are in the process (Mahn, 2005, 2008). One of the participants in the Vygotsky workshop addressed this important concept: "It is interesting and important in education to know that the conception that each one of the learners has about a concrete or abstract object can vary depending on when it is developed."

Another central area in which Vygotsky's work can enhance the theoretical framework of concept mapping theory is his analysis of how children learn scientific concepts, how they learn science. He studied the processes

through which children acquire everyday, or spontaneous, concepts and how this established the foundation for the learning of scientific concepts (1987). Unlike others at his time who posited that scientific concepts replaced everyday concepts, Vygotsky analyzed the relationship between the two and in the process developed the theory for which he is best known – the zone of proximal development, which he described as the link between scientific concepts and everyday concepts. Concept mapping is an activity that could help to develop scientific concepts in that zone; however, more specific research has to be done to understand how to represent the relationship between scientific and everyday concepts in concept maps.

Exploring ways in which Vygotsky's work can amplify the theoretical framework of concept mapping theory has been a goal of the collaboration of Mahn and Aguilar Tamayo. By applying both theories in practice and seeing ways in which each can help inform the other, they have seen the power of the combined theories. Mahn's and Aguilar Tamayo's next step in their collaboration will be in amplifying concept mapping theory using Vygotsky's analysis of concept formation.

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CMAPANALYSIS: AN EXTENSIBLE CONCEPT MAP ANALYSIS TOOL

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Abstract. CmapAnalysis is a software tool that facilitates performing various analysis measures on a collection of concept maps. A set of measures that consider size, quality and structure properties of the maps are included. The program is designed to be extensible, allowing users to add their own measures. The output of CmapAnalysis is an Excel spreadsheet that can be further analyzed.

1 Introduction

Concept maps have been used for many years as a tool for people of all ages and all domains of knowledge to express their understanding about a topic. More specifically, in education concept maps have been shown to be useful as a tool for teachers to assess students' understanding, whether at the beginning, process, or end of the study of a topic (Novak & Cañas, 2004). However, concept maps themselves have to be "assessed" – that is, the concept maps constructed by students need to be assessed by the instructor to get an appreciation of the student's understanding (and possibly assign a grade). Many assessment rubrics have been proposed, beginning with that proposed by Novak & Gowin (1984).

Although Ruiz-Primo and Shavelson (1996) have reported problems in using concept mapping as an assessment tool, there are many studies showing that concept mapping is an appropriate tool for testing students achievement (Fischler, et al., 2002; McGaghie, McCrimmon, Thompson, Ravitch, & Mitchell, 2000; Reiska, 2005; West, Pomeroy, Park, Gerstenberger, & Sandoval, 2000). Some of the studies also show that there is a high correlation between the concept mapping and other knowledge tests (Mikelskis, 1999) but some studies did not prove the correlation between concept map scores and e.g. multiple choice exam performance (McGaghie, et al., 2000).

One of the difficulties of applying assessment rubrics or algorithms is the time it takes to apply them to a large number of concept maps. If the class is large, or if the assessment is being done for research purposes on a large number of Cmaps, the time to manually analyze the maps, or transcribe their content for analysis, can be considerable.

Automatic assessment of concept maps has been included as part of several concept mapping tools, e.g. C-Tools (Harrison, Wallace, Ebert-May, & Luckie, 2004), COMPASS (Gouli, Gogoulou, Papanikolaou, & Grigoriadou, 2003) and CRESST (Herl, O'Neil, Chung, Dennis, & Lee). These systems are concept map editors with an assessment tool incorporated. They don't lend themselves to evaluating a large collection of concept maps for research purposes, or applying different types of assessment criteria to a set of maps.

CmapAnalysis is a software tool that facilitates the analysis of sets of concept maps utilizing various algorithms, rubrics and techniques. The tool provides a set of assessment options by default, and can be extended by the user to apply other assessment techniques that he/she defines. We don't propose or recommend that CmapAnalysis be used as an "automated" concept map assessment tool, and that instructors take its results as grades to be assigned to the maps. On the contrary, we propose that by automatically performing the routine operations of the analysis, instructors, and researchers, can dedicate more time to evaluate the results of the analysis and what they mean and represent. CmapAnalysis does not include a concept map editor, it presumes that the concept maps have already been constructed and

stored in the CXL format (Cañas, Hill, et al., 2006).

2 Assessment Algorithms & Techniques

The content of a concept map can be divided into three general categories (Reiska, 2005):
1. Size
2. Quality
3. Structure

Size describes how many concepts, linking words and propositions are in a concept map. Typical measures in this category are Number of Concepts (or Concept Count), Number of Linking Words and Number of Propositions. Measures from this category also describe students' knowledge. Students with more knowledge about certain topic and focus question usually include more concepts and linking words in their concept maps. However, measures from this category alone can also mislead, because large number of proposition does not mean always that the student has good knowledge – the propositions can also be incorrect. All measures in category Size are quantitative and can be calculated automatically.

Quality describes what kind of concepts, linking words and propositions are in a concept map. Typical measures in this category are Number of Correct Propositions (or Correct Proposition Count), Average Rating of Propositions, and Relevance of Concepts. The evaluation of propositions is mostly carried out with expert rating. That means that propositions will be rated by experts or compared with the propositions from expert concept map or an expert reference matrix. Quality measures can be qualitative and quantitative. To calculate the measures in this category additional information is needed. This information is commonly provided via expert ratings in the form of concept maps or ratings matrices.

Structure describes how the concepts are connected to each other. Typical measures in this category are Centrality of Concepts, Number of Cross Links, Density, and Inter-Cluster Proposition Count. The measures from this category provide information on how well the concepts are connected, such as whether there are any central concepts, are there any separate sub maps, is the map a "chain", a "tree" or a "star" (one central concept). The structural measures provide useful information, however the use of these measures without measures from other categories gives us limited information about the knowledge of students. All measures in category Structure are quantitative and can be calculated automatically.

While the measures from first two categories (Size and Quality) provide information that can be gathered with other testing methods (e.g. essay or multiple choice test), the Structure measures are unique for concept maps. Combining the measures for Structure with the measures for Quality offers unique information. Analyzing concept maps from this point of view has not well developed yet. One of our aims with CmapAnalysis is to develop a flexible tool that allows the researcher (or teacher) to create their own measures, in particular measures that combine Quality and Structure. Soika, Reiska & Mikser (2010) used CmapAnalysis to find out how the knowledge and the structure of mental models are influenced by the animation and the paper instruction by upper secondary level chemistry students.

3 CmapAnalysis

CmapAnalysis is a cross-platform application that enables users to define and execute analyses over sets of concept maps. The result of the analysis is a Microsoft Excel spreadsheet containing one row for each concept map in the analyzed set with columns for each of the desired measures. Measures range from simple counts of concepts and propositions to more complex calculations such as identifying the top three most central concepts in each map.

CmapAnalysis was designed with several objectives in mind:

a. CmapAnalysis should support Size, Quality and Structure measures in the analysis of concept maps, as described above.

b. CmapAnalysis should take as input Cmaps in the open CXL file format in addition to the .cmap format, allowing the analysis of concept maps developed by concept mapping programs that utilize CXL.

c. CmapAnalysis can handle large sets of concept maps, calculating the measures in (a) to all the maps.

d. In addition to the analysis measures incorporated into the program described below, CmapAnalysis should be extensible, meaning that users (with technical inclination) should be able to add other measures to the program.

e. The results provided by the program should be in a format that lends to further analysis (e.g. Excel spreadsheet).

4 Using CmapAnalysis

Selecting the set of maps to analyze involves browsing for a folder in the computer's file system. The tool recursively searches the selected folder for Cmaps in either the CmapTools (Cañas, et al., 2004) binary format (.cmap) or the concept map open XML format (.cxl). The CXL format is preferred since the analysis tool leverages standard XML technologies to perform its task (see Section X).

Configuring the content of the analysis involves selecting the set of desired measures from a menu where each measurement defines a column in the resulting table, as shown in Figure 1. The tool has several groups of predefined measures including basic Cmap information, topological characteristics and topological taxonomy score (Cañas, Novak, et al., 2006), and centrality measures concerning the level of connectedness among concepts in the map. These groups of measures can be applied with very little if any configuration. The groups of measures for concept clusters and for scoring propositions require the user to provide additional input such as a list of concepts or propositions. The results of running CmapAnalysis on a set of expert Cmaps as specified in Figure 1 are shown in Figure 2.

4.1 Measures included in CmapAnalysis

Basic Cmap Info Measures: include all of the metadata properties of the concept map, many of which are editable through the CmapTools map Properties window. The measures include:

- Author Email: the email address of the creator of the concept map that can be blank.
- Author Name: the name of the creator of the concept map that can be blank.
- Author Organization: the name of the author's organization that can be blank.
- CmapTools Version: the version of the CmapTools client last used to save the map.
- Date Created: the date the map was created in the format YYYY-MM-DDTHH:MM:SS-GMT, for example 2006-01-05T16:02:46-06:00.
- Date Last Modified: the date of the last save made to the concept map in the same format as Date Created.
- Language: a two character ISO-639 code (http://www.loc.gov/standards/iso639-2) representing the language of the map content, for example 'en' for English and 'es' for Spanish.
- Size: the size of the concept map in bytes as of the last time the map was saved.
- Title: The name of the concept map that is the same as the file name without the .cmap or .cxl extension.

Topological Taxonomy Measures include the topological taxonomy score (Cañas, Novak, et al., 2006) between 0 and 5 where higher scores typically indicate higher quality concept maps. This group of measures also includes the following individual aspects of the concept map that are considered in calculating the taxonomy score:

- Avg Words per Concept: the total count of words, as separated by whitespace, in all concepts divided by the number of concept in the map. Concise concepts are important to the taxonomy score.
- Branch Point Count: the total number of concepts and linking phrases that have at least one incoming connection and more than one outgoing connection.
- Concept Count: the number of concept in the map.
- Linking Phrase Count: the number of linking phrases in the map.
- Orphan Count: the number of concepts in the map that have no connections.
- Proposition Count: the number of propositions (i.e. concept-linking phrase-concept) in the map.
- Root Child Count: the number of concepts in the map that have an incoming connection from a root concept. A

root concept is defined as one that has outgoing connections but no incoming connections.

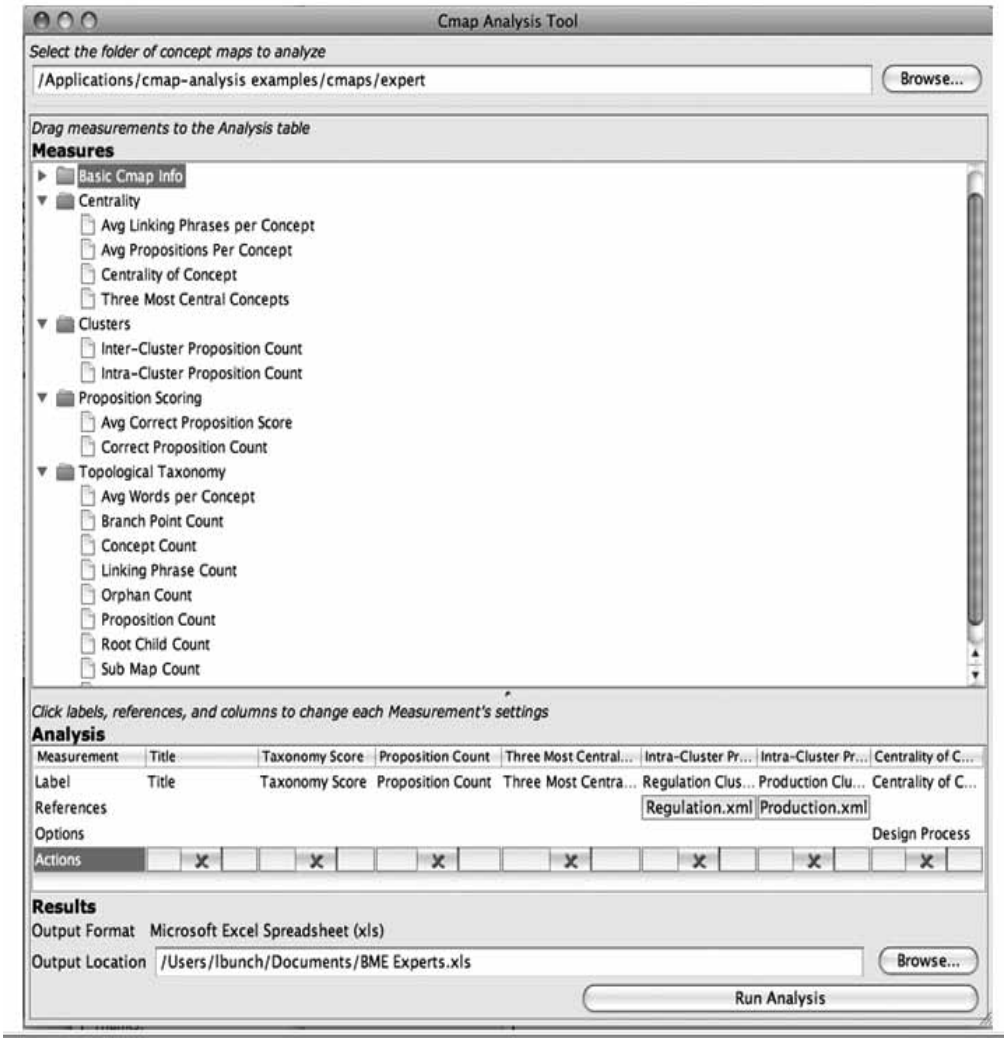


Figure 1. A Screenshot of the CmapAnalysis tool's dialogue box to define the analysis measurements.

Centrality Measures concern the connectedness of the concepts in the map, and include:

- Avg Linking Phrases per Concept: the ratio of linking phrases to concepts.
- Avg Propositions per Concept: the ratio of propositions to concepts.
- Centrality of Concept: the number of connections into and out of a given concept. The user provides a concept label in the Option field for this measure. The tool searches for the first occurrence of a concept with a matching label, ignoring whitespace and the case of the letters in the concept, and computes the Centrality of this concept.
- Three Most Central Concepts: a comma-separated list of the text labels from the three concepts with the highest centrality measure in the map.

Proposition Scoring Measures involve comparing the propositions in the map to a list of propositions provided by the user as an XML file that is selected using the References field of the measurement definition. We are aware that editing XML files is not a user-friendly interface and hope to correct this in future versions of CmapAnalysis. The following example illustrates the XML format for the list of propositions:

```
<proposition-score-list xmlns:cm="http://cmap.ihmc.us/xml/cmap/">
<cm:proposition score=".75">
      <cm:concept label="BME Design Process"/>
      <cm:linking-phrase label="involves"/>
      <cm:concept label="brainstorming"/>
   </cm:proposition>
   <cm:proposition score=".5">
      <cm:concept label="FDA approval"/>
      <cm:linking-phrase label="leads to"/>
      <cm:concept label="product on the market"/>
   </cm:proposition>
</proposition-score-list>
```

- Correct Proposition Count: the number of propositions in the concept map that match one of the propositions in a given list. Whitespace and letter case are ignored for the comparison. Proposition scores are not considered by this measurement.
- Avg Correct Proposition Score: sums the score value for all propositions in the map that match one in the given scored proposition list, then divides this score sum by the number of propositions in the map that were matched.

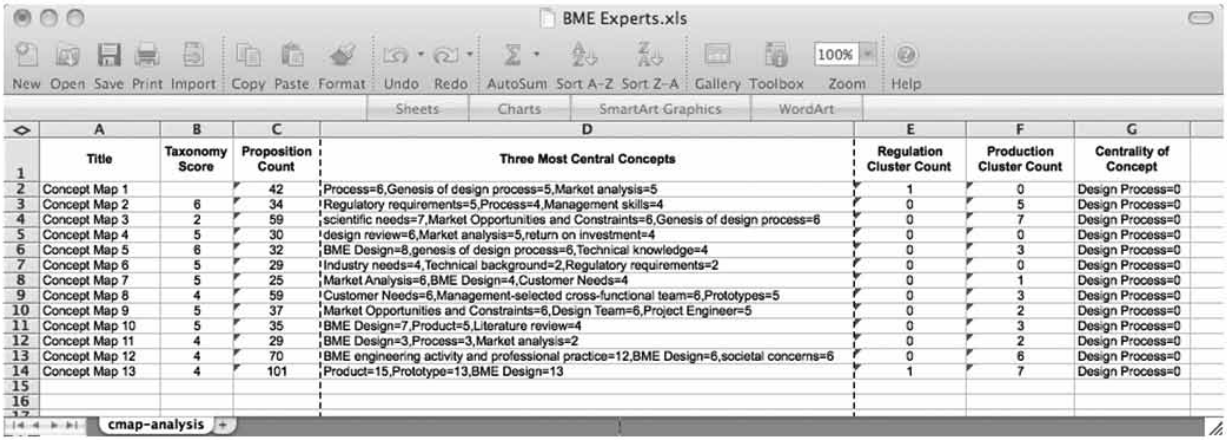
Cluster Measures provide a way to analyze relationships among groups of concepts with a map, for example the number of propositions in the map that relate key physics concepts with key chemistry concepts. These measures are configured with a single XML file that defines a list of one or more clusters where each cluster is a named list of concepts. We expect that a future version of CmapAnalysis will provide a more user-friendly interface for defining the clusters.

```
<cluster-list xmlns:cm="http://cmap.ihmc.us/xml/cmap/">
   <cluster id="Design">
      <cm:concept label="Design Process"/>
                  <cm:concept label="design"/>
                  <cm:concept label="innovation"/>
         </cluster>
   <cluster id="Production">
      <cm:concept label="Marketing"/>
                  <cm:concept label="product"/>
      <cm:concept label="manufacturing"/>
   </cluster>
</cluster-list>
```

- Intra-Cluster Proposition Count: the number of propositions in the map that occur within a given cluster. Intra-cluster propositions have both concepts defined in a single given concept cluster. For this measure, the provided XML cluster definition file should include only one cluster.
- Inter-Cluster Proposition Count: the number of propositions in the map that occur between concepts in the given clusters. Inter-cluster propositions have a concept in one of the given clusters and a concept in another cluster. For this measure, the XML cluster definition file should include at least two concept clusters.

5 CmapAnalysis Implementation

The analysis tool takes advantage of the CXL format of the concept maps to apply powerful standard XML processing and query tools to implement the analysis. The analysis execution step is defined as a transformation from the collection of maps as XML documents to a single resulting XML document in the Microsoft Excel format. We use a combination of the Extensible Stylesheet Language Transformation (XSLT) and XML Query Language.



	A	B	C	D	E	F	G
1	Title	Taxonomy Score	Proposition Count	Three Most Central Concepts	Regulation Cluster Count	Production Cluster Count	Centrality of Concept
2	Concept Map 1		42	Process=6,Genesis of design process=5,Market analysis=5	1	0	Design Process=0
3	Concept Map 2	6	34	Regulatory requirements=5,Process=4,Management skills=4	0	5	Design Process=0
4	Concept Map 3	2	59	scientific needs=7,Market Opportunities and Constraints=6,Genesis of design process=6	0	7	Design Process=0
5	Concept Map 4	5	30	design review=6,Market analysis=5,return on investment=4	0	0	Design Process=0
6	Concept Map 5	6	32	BME Design=8,genesis of design process=6,Technical knowledge=4	0	3	Design Process=0
7	Concept Map 6	5	29	Industry needs=4,Technical background=2,Regulatory requirements=2	0	0	Design Process=0
8	Concept Map 7	5	25	Market Analysis=6,BME Design=4,Customer Needs=4	0	1	Design Process=0
9	Concept Map 8	4	59	Customer Needs=6,Management-selected cross-functional team=6,Prototypes=5	0	3	Design Process=0
10	Concept Map 9	5	37	Market Opportunities and Constraints=6,Design Team=6,Project Engineer=5	0	2	Design Process=0
11	Concept Map 10	5	35	BME Design=7,Product=5,Literature review=4	0	3	Design Process=0
12	Concept Map 11	4	29	BME Design=3,Process=3,Market analysis=2	0	2	Design Process=0
13	Concept Map 12	4	70	BME engineering activity and professional practice=12,BME Design=6,societal concerns=6	0	6	Design Process=0
14	Concept Map 13	4	101	Product=15,Prototype=13,BME Design=13	1	7	Design Process=0
15							
16							

Figure 2. Excel spreadsheet with the results of running CmapAnalysis on a set of Cmaps from experts as specified in Figure 1.

(XQuery) to walk through the set of concept maps and compute each of the selected measurements for that map. To illustrate the power of XLST, the code to obtain the count of concepts in a map is simply:

```
count( $map/cm:cmap/cm:map/cm:concept-list/cm:concept )
```

where count is a built-in XLST function, $map is the collection of CXL documents, and the remaining text is just the path to the <concept> elements within the XML document structure.

XQuery similarly provides a very concise and expressive language for analyzing the content of XML documents. For example, the code to find the list of propositions involves 'joining' each linking phrase to the list of connections and concepts:

```
for $lp in $map//cm:linking-phrase
let $conn1 :=
$map/cm:cmap/cm:map/cm:connection-list/cm:connection[@to-id = $lp/@id],
$conn2 :=
$map/cm:cmap/cm:map/cm:connection-list/cm:connection[@from-id = $lp/@id],
$cpt1 :=
$map/cm:cmap/cm:map/cm:concept-list/cm:concept[@id = $conn1/@from-id],
$cpt2 :=
$map/cm:cmap/cm:map/cm:concept-list/cm:concept[@id = $conn2/@to-id]
for $i in (1 to count($cpt1)),
   $j in  (1 to count($cpt2))
    return
       <cm:proposition> {$cpt1[$i], $lp, $cpt2[$j]} </cm:proposition>
```

This XQuery function returns a list of propositions represented in XML:

```
<proposition><concept/><linking-phrase/><concept/></proposition>
```

Since the results are also in XML format, they can be used as input to other XQuery calculations. This is exactly how the 'Correct Proposition Count' measurement is implemented. It first obtains the proposition list from the map, joins this intermediate XML result with the user-provided list of correct propositions to identify matches.

Another useful feature of XQuery is the ability to call-out to a procedural language such as Java. The topological taxonomy score is computed by using such a call to a Java method with the current concept map's XML content as a

parameter. This allowed us to reuse the Java implementation of the taxonomy scoring that was implemented for use within CmapTools.

The analysis tool defines a 'shell' XQuery algorithm that handles setting up the collection of CXL documents, iterating through this set of maps, invoking each measurement's XQuery code on each CXL map, and organizing the results into a table of rows and columns that Microsoft Excel can understand. Each measurement defines just the XSLT or XQuery code necessary to calculate the value for a single concept map and produces a text or numeric result. Our hope is that this level of modularity will enable others to easily create and share new measurements without needing to understand the code of the analysis tool itself, but rather just the CXL format and the standard XML technologies.

6 Extending CmapAnalysis

The analysis tool contains a directory named 'measurements'. Each folder in this directory defines one of the groups of measurements that appear in the user interface. Within each of these measurement group folders is an XML file for each measurement. The folder names and file names are used directly by the analysis tool to populated the user interface, so creating a new group of measurements or reorganizing them involves simply creating new folders and rearranging the XML files within.

Measures are defined as XML documents with the following format.

```
<cmap-measure>
    <Label>Avg Words per Concept</Label>
    <Description></Description>
    <DataType>Number</DataType>
    <XQueryExpression>
    if (count( local:concept-words($map)/cm:concept) > 0) then
(
            round-half-to-even(
            count( local:concept-words($map)/cm:concept/cma:word)
  div
  count( local:concept-words($map)/cm:concept)
            , 5 )
    )
            else 0.0
   </XQueryExpression>
    <XQueryFunctions>
declare function local:concept-words($map as document-node()) as element(concept-word-list)
    {
    <concept-word-list>
    {
            for $concept in $map/cm:cmap/cm:map/cm:concept-list/cm:concept
                    return
            <cm:concept>
        {
          for $i in tokenize($concept/@label, "\s+" )
          return <cma:word>{$i}</cma:word>
         }
        </cm:concept>
        }
    </concept-word-list>
    };
</XQueryFunctions>
</cmap-measure>
```

- Label: the default text to use as the column heading for the measure.
- Description: the text description of the measurement.
- DataType: identifies whether the results are a Number or a String (i.e. text). This is used to display the column of results correctly in Excel.
- XQueryExpression: the XQuery code that will be executed to compute the measurement. This code is inserted into the 'shell' XQuery that the analysis tool defines so that the variable $map will always be defined and contain the XML for the current concept map. The code defined by the measurement computes the value for a single map and the analysis tool takes care of applying this measure to all of the selected maps.
- XQueryFunctions: XQuery supports defining functions that can be called from within the XQueryExpression as shown in the example above where the 'Avg Words per Concept' expression calls the 'concept-words' function to obtain a list of all the words in a given concept. These functions typically return an XML result that is then used by the calling XQuery expression.
- The XQuery code for the analysis shell (analysis-shell.xml) is also provided with the tool for developers to potentially modify or extend to suit their needs. This shell document defines several functions that can be reused and called from within the XQueryExpression or XQueryFunctions sections of any measurement definition. These functions include obtaining an XML list of propositions and branch points as well as other useful features like finding the list of concepts connected to a given one.

7 Future Work

CmapAnalysis is fully operational and in use by researchers and instructors. However, being in its first version the user interface needs further work. The dialogue box used to define the measurements for the analysis needs adjustments, and using XML to specify clusters and list of propositions needs to be replaced by a proper graphical dialogue box.

8 Conclusions

CmapAnalysis is a tool that enables the automated assessment of a large number of concept maps utilizing a set of predefined measurements. It is written in Java and thus runs in a large number of platforms, including Windows, OS X and Linux. CmapAnalysis is extensible, allowing the user to define new measurements in XML. The results of CmapAnalysis' processing a set of Cmaps are stored in an Excel spreadsheet that can be further analyzed. CmapAnalysis provides both instructors and researchers with a mechanism for in-depth analysis of concept maps.

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COMPARACIÓN DEL INCREMENTO DE APRENDIZAJE OBTENIDO AL UTILIZAR MAPAS CONCEPTUALES Y CMAPTOOLS EN EL ESTUDIO DE DOS TEMAS DIFERENTES, PERO DE NIVEL DE CONTENIDO CONCEPTUAL EQUIVALENTE

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Abstract. La pregunta de enfoque que ha guiado el trabajo de investigación que se presenta en esta comunicación ha sido la siguiente: Para temas de estudio de nivel de contenidos conceptuales equivalente, ¿el incremento de aprendizaje obtenido gracias a la utilización de los mapas conceptuales y Cmaptools depende del tema estudiado? En la presente investigación se ha llevado a cabo un estudio experimental para determinar y comparar el incremento de aprendizaje que obtienen los alumnos al utilizar mapas conceptuales y CmapTools en el estudio de dos temas de un nivel de contenidos conceptuales equivalentes. Los temas elegidos han sido "Fibras Ópticas" (tema 1) y "Partículas Fundamentales de la Materia" (tema 2). El diseño de la investigación ha sido cuasi experimental con post-test, con cuatro grupos de alumnos, dos de ellos experimentales y los otros dos de control. Cada grupo ha estado formado por 57 alumnos de la Facultad de Ciencias y de diversos Másteres de postgrado de la Universidad de Extremadura (España). Los dos grupos experimentales han utilizado como metodología didáctica un modelo de conocimiento con mapas conceptuales realizados por el profesor con CmapTools. El grupo experimental 1 ha estudiado el tema referente a las fibras ópticas y el grupo experimental 2 ha estudiado el tema de las partículas fundamentales de la materia. Los dos grupos de control no han utilizado los mapas conceptuales en su proceso de aprendizaje y han estudiado respectivamente los temas señalados mediante textos facilitados por el profesor. Como instrumento de evaluación se ha diseñado un test de tipo dicotómico compuesto por 100 ítems para cada tema con un nivel de exigencia equivalente para ambos. Los test se pasaron a modo de post-test a los cuatro grupos de trabajo. Con los datos recogidos en los test, se ha realizado un análisis comparativo entre el incremento de aprendizaje obtenido por los alumnos de los grupos experimentales frente a sus respectivos grupos de control. El análisis estadístico realizado nos ha permitido afirmar que el incremento de aprendizaje conseguido al utilizar los mapas conceptuales en el estudio de dos temas distintos (pero de niveles equivalentes de contenido conceptual) es similar.

1 Introducción

Los mapas conceptuales son muy utilizados en los diferentes niveles educativos al permitir una mejor asimilación de los conceptos de un determinado tema mediante la elaboración de proposiciones nuevas que se integran en la estructura cognitiva ya existente, originando un aprendizaje significativo (Ausubel, D. P., 1982; Pérez, Suero, Montanero & Pardo, 2001). En los últimos años, los mapas conceptuales se han convertido en una herramienta eficaz para que los alumnos construyan su conocimiento mediante la organización y jerarquización de contenidos conceptuales (Novak & Gowin, 1984). El programa informático CmapTools facilita la construcción de los mapas conceptuales permitiendo que el alumno organice y estructure con facilidad los contenidos de un tema por lo que resultan de utilidad para el estudio de determinadas materias sobretodo si presentan un alto contenido conceptual (Cañas et al., 2004; Pérez, Suero, Montanero & Pardo, 2004). El objetivo general de esta investigación ha sido determinar si el incremento de aprendizaje que se obtiene al utilizar los mapas conceptuales en el estudio de dos temas con un nivel de contenidos conceptuales parecido, es diferente o similar en función de cual sea la materia objeto de estudio. Para conseguir este objetivo se determinó experimentalmente el incremento de aprendizaje obtenido por los alumnos al utilizar los mapas conceptuales para estudiar las "Fibras Ópticas" (tema 1) y en el estudio de las "Partículas Fundamentales de la Materia" (tema 2). Los resultados obtenidos con el estudio estadistico comparativo realizado han puesto de manifiesto que, el tema estudiado no influye significativamente en el incremento de aprendizaje obtenido, siempre que se comparen temas que tenga un nivel de contenidos conceptuales parecidos.

2 Métodos

El diseño de la investigación llevada a cabo ha sido de tipo cuasi-experimental con post-test y grupo de control. Para ello se han utilizado 4 grupos de alumnos, dos de ellos de control (G.C.) y los otros dos experimentales (G.E.).
Los grupos de control 1 y 2 han estudiado sin la utilización de los mapas conceptuales los temas 1 y 2 respectivamente. Los grupos experimentales 1 y 2 han utilizado los mapas conceptuales realizados por el profesor con el programa

Cmaptools para el estudio de los temas señalados.

El primer tema elegido fue el de las “Fibras Ópticas”. En la comunicación “Determinación experimental del incremento de aprendizaje obtenido mediante la utilización de mapas conceptuales y CmapTools. Comparación de la cantidad de aprendizaje obtenido en el estudio de las fibras ópticas utilizando mapas conceptuales y sin utilizarlos”, se describe como se obtuvo el incremento de aprendizaje conseguido al utilizar los mapas conceptuales. El segundo tema que se eligió fue el de las “Partículas Fundamentales de la Materia” por ser un tema con un nivel de contenido conceptual similar al de las Fibras ópticas. Ambos temas no habían sido estudiados con anterioridad a este nivel por los alumnos que formaron parte de los grupos de trabajo. Esta elección garantizaba que los alumnos tendrían unos conocimientos iniciales mínimos sobre esos temas y minimizaba la influencia que podría presentar la variable interferente “conocimientos previos” sobre los resultados obtenidos.

Los mapas conceptuales que utilizaron los grupos experimentales 1 y 2 se enlazaron entre sí formando un modelo de conocimiento utilizando el programa CmapTools. Estos mapas se encuentran alojados en nuestro sitio Cmap “Universidad de Extremadura (España)” dentro de la carpeta “Comunicaciones a Congresos” http://grupoorion.unex.es:8001/servlet/SBReadResourceServlet?viewhtml desde donde pueden ser utilizados de manera interactiva mediante la aplicación informática CmapTools. En las figuras 1 y 2 se muestran los epítomes generales de los modelos de conocimiento realizados.

Como instrumento de evaluación se diseñaron dos test iniciales compuestos por 120 preguntas cada uno y se pasaron a un grupo piloto de veinte alumnos que no iban a formar parte de la investigación posterior. Se rechazaron los 20 ítems de cada uno de ellos que ofrecieron resultados menos significativos. De esta manera se obtuvieron dos test de tipo dicotómico compuestos de 100 ítems cada uno (que también están disponibles en nuestro sitio Cmap). Con los resultados obtenidos en estos test, se realizó un análisis estadístico-descriptivo para determinar los incrementos de aprendizaje obtenidos por los alumnos de los grupos experimentales frente a los grupos de control.

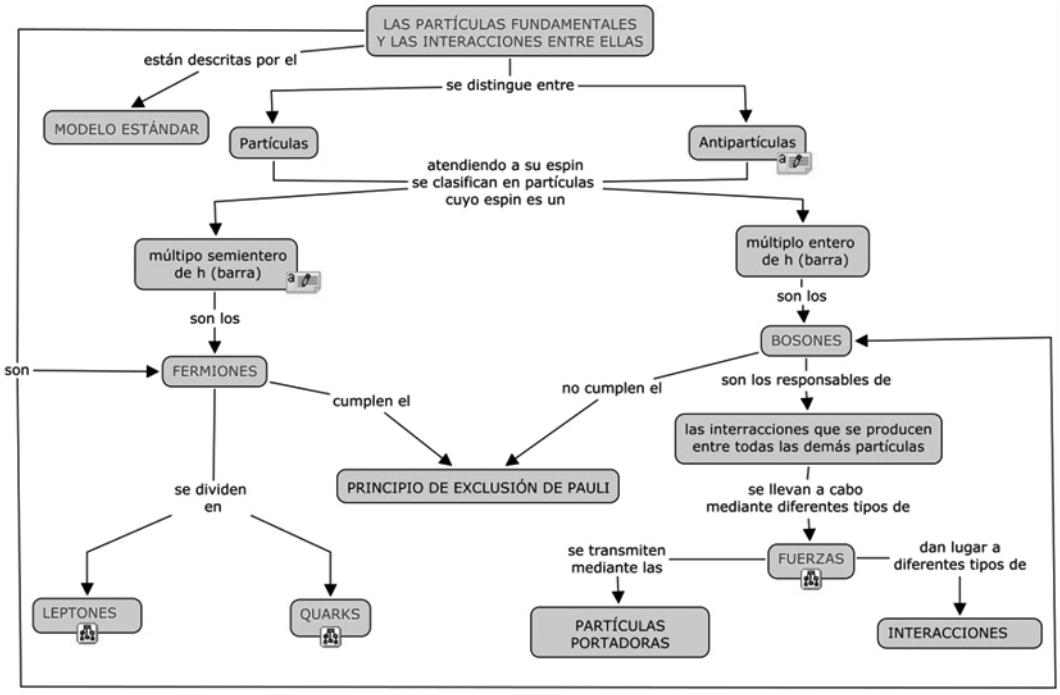


Figura 1. Epítome general del modelo de conocimiento elaborado sobre las Partículas Fundamentales de la Materia

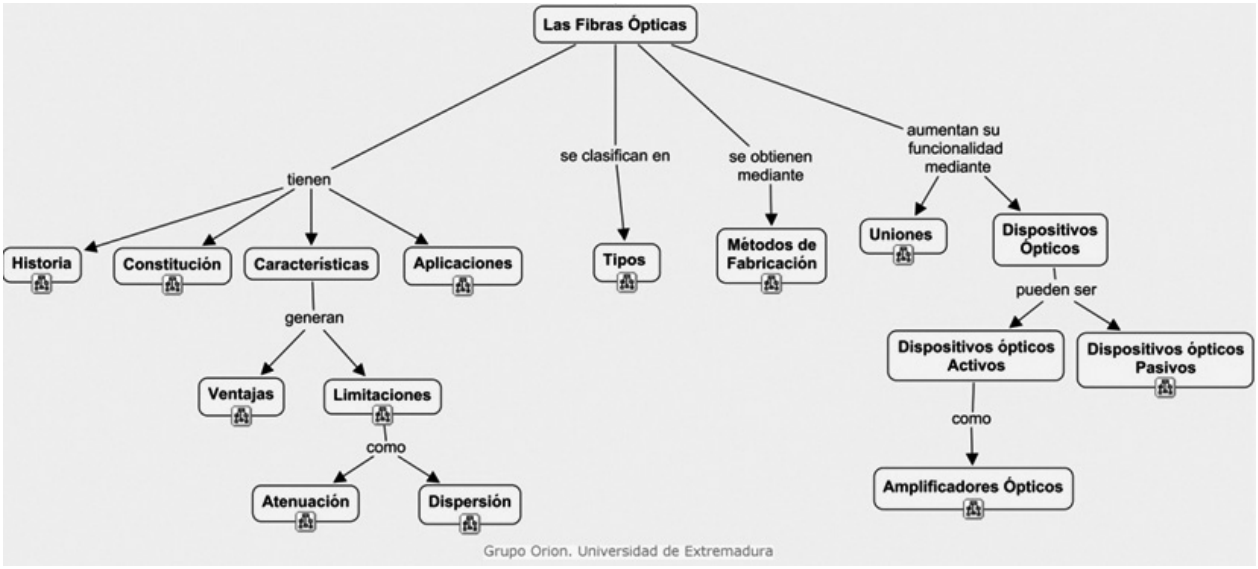


Figura 2. Epítome general del modelo de conocimiento elaborado sobre las Fibras Ópticas

3 Resultados y Discusión

Para analizar los datos recogidos en los test de evaluación que fueron pasados a los alumnos, se ha utilizado el paquete estadístico PASW Statistics 18. En la Tabla 1 se muestran los resultados de las medias de las calificaciones obtenidas por los alumnos en el estudio de las Fibras ópticas. En la tabla se recogen los resultados promedios obtenidos por el G.E. 1, el G.C. 1 y el incremento de aprendizaje (ΔA) obtenido por el G.E. frente al G.C.

Tema: Fibras ópticas		**Grupo Experimental 1**	**Grupo Control 1**	**Δ Aprendizaje (ΔA)**
N	**Items**	100	100	100
Media		**83,51**	**61,74**	**21,77**
Desviación típica		**7,94**	**12,25**	**10,45**
Percentil	25	78,94	54,39	14,03
	75	89,47	70,17	29,82

Tabla 1. Análisis estadístico descriptivo de las respuestas del G.C. y del G.E. en el estudio de las Fibras Ópticas

En la Tabla 2 se muestran los resultados promedio obtenidos en el test de evaluación del tema Partículas Fundamentales de la Materia. En la cuarta columna se muestra el incremento de aprendizaje obtenido por el G.E. 2 frente al G.C. 2.

Tema: Partículas Fundamentales de la Materia		**Grupo Experimental 2**	**Grupo Control 2**	**Δ Aprendizaje (ΔA)**
N	**Items**	100	100	100
Media		**82,42**	**62,88**	**19,54**
Desviación típica		**8,17**	**10,80**	**9,46**
Percentil	25	77,49	55,36	12,98
	75	88,68	70,88	26,71

Tabla 2. Análisis estadístico descriptivo de las respuestas del G.C. y del G.E. en el estudio de las Partículas Fundamentales de la Materia

Podemos apreciar que existe una diferencia entre las medias obtenida por los grupos experimentales y los de control en el estudio de ambos temas. En la Tabla 3 se muestra el resultado de la prueba de Levene de igualdad de

varianzas y de la prueba t para la igualdad de medias para el estudio de las Partículas Fundamentales de la Materia.

	Prueba de Levene para la igualdad de varianzas		Prueba T para la igualdad de medias					
	F	Sig.	t	Sig. (bilateral)	Diferencia de medias	Error típico de la diferencia	95% Intervalo de confianza para la diferencia	
							Inferior	Superior
Partículas Fundamentales	8,34	0,004	14,4	0,00	19,54	1,35	16,87	22,21

Tabla 3. Prueba t para muestras independientes para un p-valor $p < 0.05$ Tema: Partículas Fundamentales de la Materia.

Los resultados obtenidos en la prueba de Levene y en la prueba t para la igualdad de medias, nos permitieron afirmar un intervalo de confianza del 95% que el incremento de aprendizaje medio obtenido en cada ítem por los alumnos que usan los mapas conceptuales para el estudio de las partículas fundamentales de la materia está entre el 16,87% y el 22,21%.

En la Tabla 4 se muestran los resultados obtenidos en la media, desviación típica, coeficiente de variación y error típico de la media para los dos grupos de control. Se aprecia que el grupo de control 1 tiene un porcentaje de aciertos promedio de 61,74 con una desviación típica de 12,25 y el grupo de control 2 tiene un porcentaje de aciertos promedio de 62,88 y una desviación típica de 10,80. El coeficiente de variación del grupo de control 1, [C.V. = (12,25/61,74)] es de 0,198 y el del grupo de control 2, [C.V. = (10,80/62,88)] es de 0,171, lo que nos indica que el grupo de control 2 tiene una distribución de notas algo más homogénea que el grupo de control 1. Con los datos obtenidos en estos grupos se ha representado gráficamente el histograma y la curva Gaussiana de la distribución de frecuencias (Figura 3).

Comparación de los G. C.	N	Media	Desviación típica	Coeficiente de Variación (C.V.)	Error típico de la media
Grupo Control 1	100	61,73	12,25	0,198	1,22
Grupo Control 2	100	62,87	10,80	0,171	1,08

Tabla 4. Comparación de la media, desviación típica, error típico y coeficiente de variación para los grupos de control

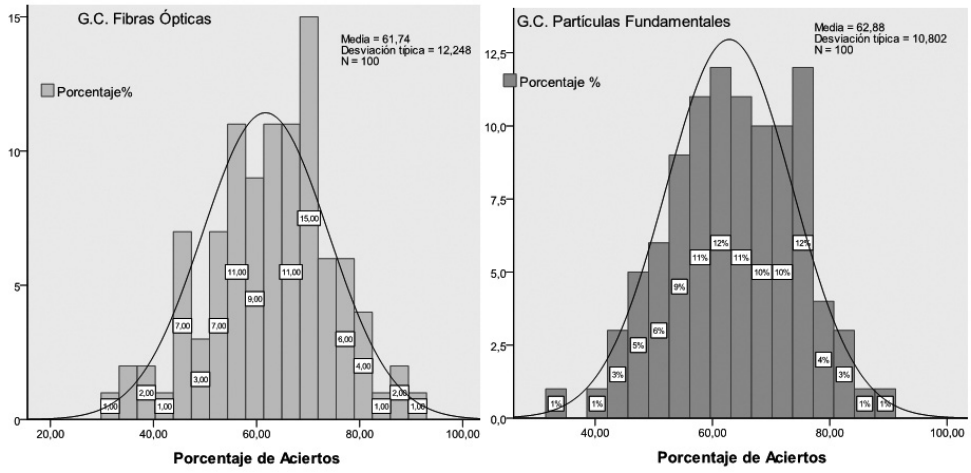


Figura 3. Histograma del porcentaje de aciertos y curva normal de distribución superpuesta del grupo de control 1, tema "Fibras ópticas" (izquierda) y del grupo de control 2, tema "Partículas Fundamentales de la Materia" (derecha)

Se observa que existe una diferencia en los valores encontrados en las medias de los grupos de control 1 y 2. Para comprobar si esa diferencia entre las calificaciones promedio obtenidas es significativa a un nivel de significación de

un 5% (α=0.05), se aplicó la prueba de Levene y una prueba t de student para la igualdad de medias para muestras independientes. El objetivo de esta comparación entre los dos grupos de control es determinar si las calificaciones promedio obtenidas por ambos grupos son análogas, para comprobar si la dificultad que presentan los dos temas elegidos es similar o no. En la Tabla 5 se muestran los resultados obtenidos en estas pruebas.

Diferencias entre Grupos de Control			Se han asumido varianzas iguales	No se han asumido varianzas iguales
Prueba de Levene para la igualdad de varianzas	F		1,012	
	Significación		0,316	
Prueba T para la igualdad de medias	t		0,698	0,698
	gl (grados de libertad)		198	194,956
	Significación (bilateral)		0,486	0,486
	Diferencia de medias		1,140	1,140
	Error típico de la diferencia		1,633	1,633
	95% Intervalo de confianza para la diferencia	Inferior	-2,080	-2,080
		Superior	4,360	4,361

Tabla 5. Prueba de Levene y prueba t para muestras independientes para un p-valor $p < 0.05$. Grupos de Control

La prueba de Levene realizada mostró similitud entre las varianzas de los grupos ya que el valor de la significación obtenida en esta prueba ha sido de 0.316, es decir, se ha obtenido un valor mayor al p-valor marcado del 5%. (0.316> 0.05). Las evidencias de normalidad en los datos de los grupos que se compararon, permitieron hacer la prueba t de comparación de medias, para detectar si había o no diferencias significativas en cuanto a las calificaciones promedio obtenidas en los test de evaluación de los grupos de control. En la Tabla 5 se observa que la diferencia de medias encontrada ha sido de 1,14 con un error típico de 1.63. La significación bilateral que resulta de la prueba t es de 0.486, valor que excede del p-valor marcado de 0.05. Como este valor de la prueba t es mayor que el nivel de significación elegido (α=0.05), esto nos permite afirmar que la diferencia encontrada entre ambos grupos no es significativa para un nivel de significación del 95%. Este resultado corrobora que los alumnos de los grupos de control obtienen calificaciones promedio similares en el estudio de los dos temas elegidos cuando el nivel de exigencia establecido para ambos es similar, resultado que nos permite asegurar que la dificultad que presentan ambos temas al nivel estudiado para los dos grupos de alumnos era equivalente.

Partiendo de esta equivalencia de dificultad encontrada entre los temas al nivel de trabajo establecido, la siguiente pregunta que nos planteamos fue si el incremento de aprendizaje que se obtiene al utilizar mapas conceptuales y el programa CmapTools para el estudio de estas materias se vería influenciada por la elección del tema. En la Tabla 6 se muestran los valores de la media, desviación típica, error típico y coeficiente de variación de las calificaciones promedio de los grupos experimentales. Podemos observar que los coeficientes de variación de ambos grupos experimentales son muy similares (0.099 y 0.095). Esto nos indica que ambos grupos tienen una distribución igual de homogénea en las calificaciones obtenidas en los test de evaluación.

Comparación de los G. E.	N	Media	Desviación típica	Coeficiente de Variación	Error típico de la media
Grupo Experimental 1	100	83,51	7,94	0,095	0,79
Grupo Experimental 2	100	82,42	8,17	0,099	0,82

Tabla 6. Comparación de la media, desviación típica, error típico y coeficiente de variación para los grupos experimentales

En la Figura 4 se representan los histogramas de la distribución de aciertos para los grupos experimentales y la curva Gaussiana superpuesta

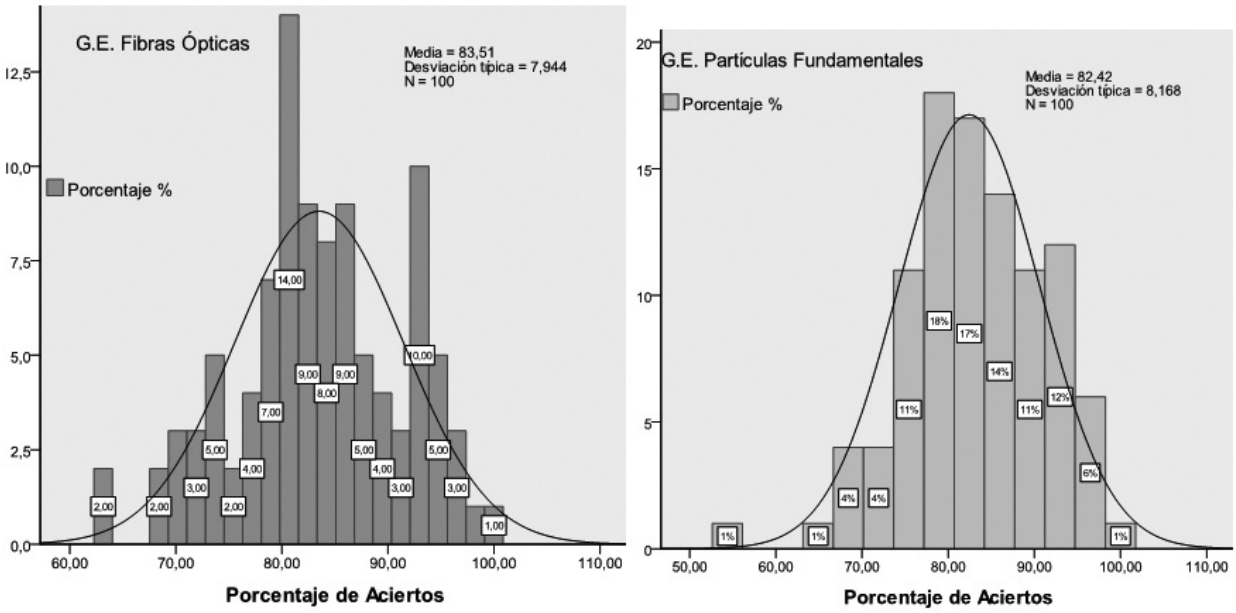


Figura 4. Histograma del porcentaje de aciertos y curva normal de distribución superpuesta del grupo experimental 1, tema "Fibras ópticas" (izquierda) y del grupo experimental 2, tema "Partículas Fundamentales de la materia" (derecha)

En la Figura 5 representamos los histogramas de los incrementos de aprendizaje alcanzado por los alumnos del grupo experimental frente a los alumnos del grupo de control en el estudio de cada uno de los temas elegidos.

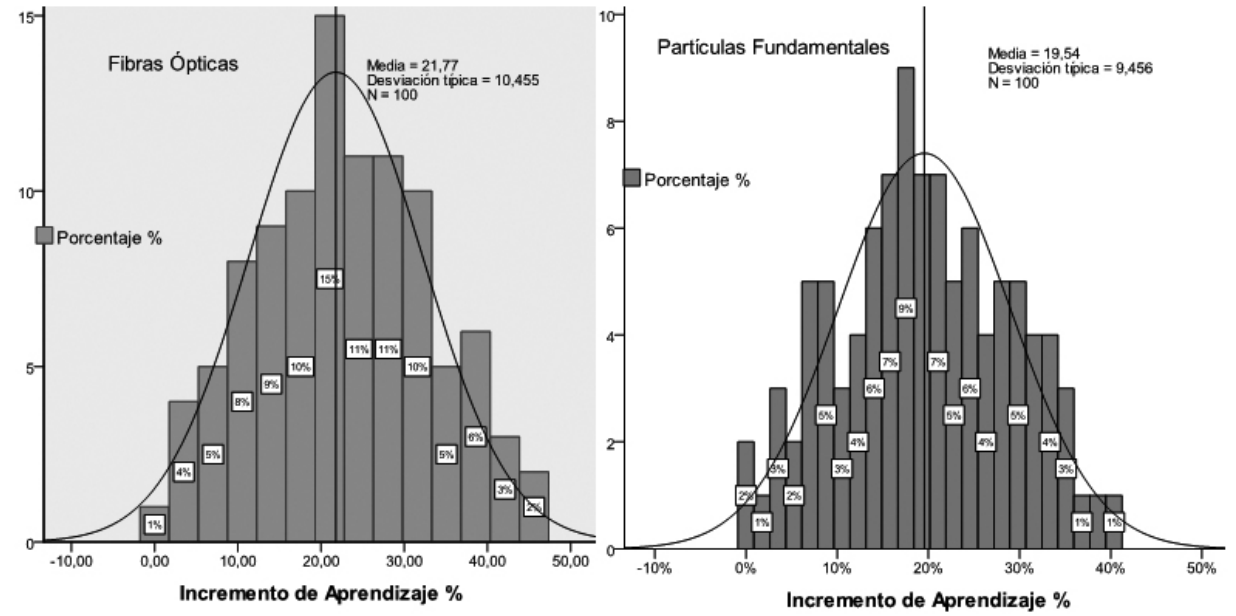


Figura 5. Histograma de la variable ΔA y curva normal de distribución superpuesta para el tema "Fibras ópticas" (izquierda) y para el tema "Partículas Fundamentales de la materia" (derecha)

Podemos observar que existe una diferencia en el incremento de aprendizaje obtenido en el estudio del tema 1 y del tema 2. Para el caso de las fibras ópticas se ha alcanzado un incremento de aprendizaje medio en cada ítem de un 21,77% y para el caso de las partículas fundamentales de la materia se ha obtenido un incremento de aprendizaje promedio en cada ítem de un 19,54%. Para valorar este incremento de aprendizaje en función de los alumnos, una vez corregidos los test de cada uno de los alumnos, se han ordenado en orden decreciente en función de las calificaciones

obtenidas, y se han emparejado los alumnos de ambos grupos, el alumno del grupo de control que consiguió mejor calificación fue emparejado con su homólogo del grupo experimental que sacó mejor nota. En la Tabla 7 se muestran los resultados en los promedios obtenidos en relación a los ítems y en relación a los alumnos.

ΔA (Análisis por ítems)	N	Media	Desviación típica	Error típico de la media
Grupo experimental 1	100	21,77	10,45	1,04
Grupo experimental 2	100	19,54	9,46	0,94
ΔA (Análisis por alumnos)	N	Media	Desviación típica	Error típico de la media
Grupo experimental 1	57	21,77	1,74	0,23
Grupo experimental 2	57	19,54	1,77	0,23

Tabla 7. Análisis de la variable incremento de aprendizaje para los dos grupos experimentales. Análisis por ítems (filas superiores) y Análisis por alumnos (filas inferiores)

Se observa que el valor obtenido para el incremento de aprendizaje en ambos temas es diferente. La pregunta que se nos planteó es ¿esta diferencia encontrada es significativa para un nivel de significación de un 5%, y por tanto, el valor del incremento de aprendizaje depende del tema estudiado? Para dar respuesta a este planteamiento se formuló la siguiente hipótesis nula H0: "No existen diferencias significativas entre el incremento medio de aprendizaje alcanzado por los alumnos que estudian con mapas conceptuales el tema de fibras ópticas frente al incremento de aprendizaje medio alcanzado por los alumnos que estudian las partículas fundamentales de la materia utilizando mapas conceptuales" Para poder rechazar o no la hipótesis nula se realizó una prueba de Levene para la igualdad de varianzas y una prueba t para la igualdad de medias. En la Tabla 8 se muestras los resultados obtenidos. Análisis de la variable incremento de aprendizaje para los dos grupos experimentales. Análisis por ítems (filas superiores) y Análisis por alumnos (filas inferiores).

En la Figura 6 se representa el histograma y la curva de distribución normal para la variable incremento de aprendizaje con los datos recogidos de las 57 parejas formadas para el tema de las fibras ópticas y de las 57 parejas formadas pata el tema de las partículas fundamentales de la materia.

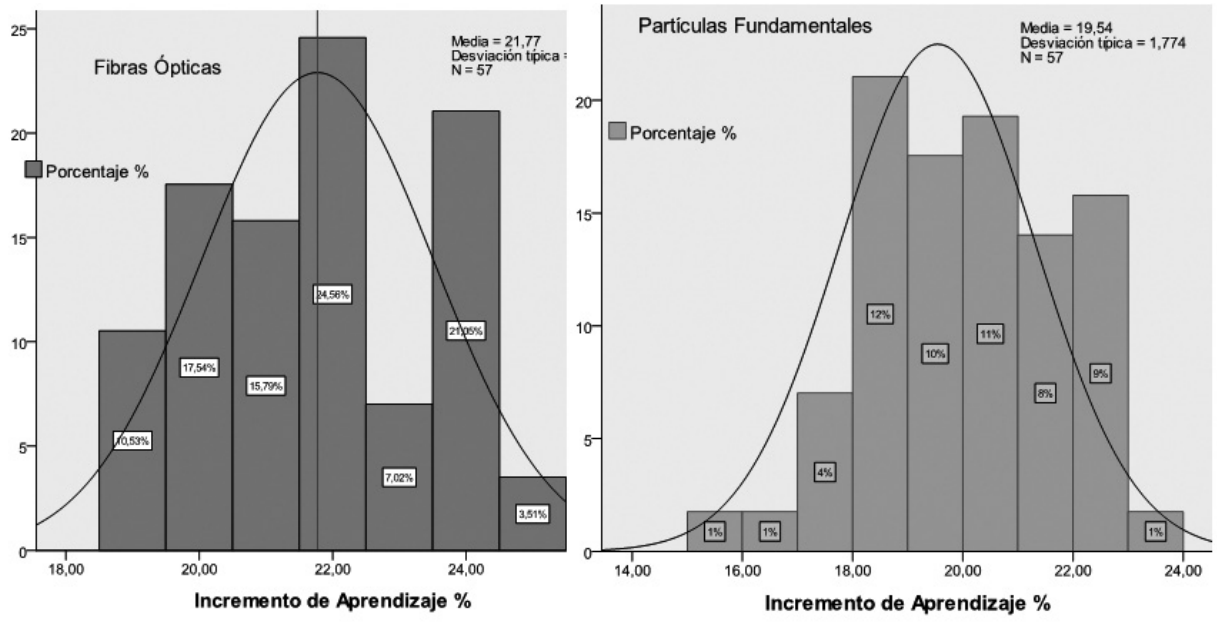


Figura 6. Histograma de la variable ΔA y curva normal de distribución superpuesta para el tema "Fibras ópticas" (izquierda) y para el tema "Partículas Fundamentales de la materia" (derecha)

Se observa que el valor obtenido para el incremento de aprendizaje en ambos temas es diferente. La pregunta que se nos planteó es ¿esta diferencia encontrada es significativa para un nivel de significación de un 5%, y por tanto, el valor del incremento de aprendizaje depende del tema estudiado? Para dar respuesta a este planteamiento se formuló la siguiente hipótesis nula H0: "No existen diferencias significativas entre el incremento medio de aprendizaje alcanzado por los alumnos que estudian con mapas conceptuales el tema de fibras ópticas frente al incremento de aprendizaje medio alcanzado por los alumnos que estudian las partículas fundamentales de la materia utilizando mapas conceptuales" Para poder rechazar o no la hipótesis nula se realizó una prueba de Levene para la igualdad de varianzas y una prueba t para la igualdad de medias. En la Tabla 8 se muestras los resultados obtenidos.

Diferencias entre el Incremento de Aprendizaje (△A)			**Se han asumido varianzas iguales**	**No se han asumido varianzas iguales**
Prueba de Levene para la igualdad de varianzas	F		0,970	
	Significación		0,326	
Prueba T para la igualdad de medias	t		-1,581	-1,581
	gl (grados de libertad)		198	196,034
	Significación (bilateral)		0,116	0,116
	Diferencia de medias		-2,228	-2,228
	Error típ. de la diferencia		1,409	1,409
	95% Intervalo de confianza para la diferencia	Inferior	-5,008	-5,008
		Superior	0,551	0,552

Tabla 8. Prueba de Levene y prueba t para muestras independientes para un p-valor $p < 0.05$

Observamos que la significación de Levene es 0.326, valor superior al p valor considerado (0.05), luego se asumen varianzas iguales. Si nos fijamos en el valor de la significación bilateral de la prueba t, obtenemos un valor de 0.116, mayor a $\alpha = 0.05$, luego la probabilidad de que la hipótesis planteada sea falsa es inferior al 5%. Este resultado nos permite aceptar la hipótesis nula y afirmar con una confianza de un 95% que cuando se comparan los promedios de los resultados obtenidos en los test, no existen diferencias significativas entre los incrementos de aprendizaje, por lo que podemos afirmar que, en un alumno, el incremento de aprendizaje obtenido al utilizar los mapas conceptuales es independiente del tema elegido, siempre y cuando tengan un nivel de contenidos conceptuales equivalente y sean estudiados a un mismo nivel de exigencia.

4 Conclusiones

Los resultados de esta investigación nos indican que existe un incremento de aprendizaje en los alumnos que utilizan los mapas conceptuales y el programa informático CmapTools frente a los que no los utilizan tanto para el estudio de las Fibras Ópticas como para el estudio de las Partículas Fundamentales de la Materia. El análisis estadístico comparativo realizado nos ha permitido afirmar que el incremento de aprendizaje conseguido al utilizar los mapas conceptuales en el estudio de dos temas distintos de nivel de contenido conceptual equivalente es similar. Es decir, los mapas conceptuales constituyen una herramienta que ayuda a los alumnos a aprender significativamente los conceptos independientemente de la materia objeto de aprendizaje siempre que su nivel de contenidos conceptual sea análogo. Estos resultados evidencian que el haber empleado mapas conceptuales ayuda a mejorar el rendimiento académico de los alumnos en el estudio de cualquier tema.

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CONCEPTGAME: UN VIDEOJUEGO BASADO EN MAPAS CONCEPTUALES

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Abstract. Este estudio consistió en diseñar, desarrollar y evaluar ConceptGame, un videojuego para generar aprendizaje a través de la construcción de representaciones conceptuales de una disciplina, utilizando la técnica de los mapas conceptuales. Para entender cómo los aprendices percibían e interactuaban con el videojuego, se realizaron pruebas preliminares de usabilidad. Los resultados muestran que ConceptGame es entendible y usable, y que los mapas conceptuales pueden ser utilizados como metodología y contenido de videojuegos con fines de aprendizaje.

1 Introducción

El uso de videojuegos para propósitos de aprendizaje ha sido uno de los temas de interés que ha surgido entre investigadores y desarrolladores. Las investigaciones se han focalizado en su utilización principalmente en el aula (Fernández-Vara & Tan, 2008). Incluso algunos estudios han determinado que los videojuegos en computador (como simuladores o juegos de aventura) permiten apoyar el desarrollo de habilidades específicas en el pensamiento crítico, pensamiento estratégico y en habilidades de planificación en los aprendices de edad escolar (Vass, 2002). Los videojuegos por computador permiten que el aprendiz genere interés en el proceso de aprendizaje, utilice al máximo sus sentidos, e incluso que construya conocimiento por medio de aplicaciones colaborativas (Sánchez, 2001). La motivación en el aprendizaje como factor determinante en un videojuego ha sido estudiada por varios autores (Prensky, 2005; Driskell & Dwyer, 1984; Kirriemuir & McFarlane, 2004). Algunos autores han señalado que los dos factores más importantes para aplicar correctamente los videojuegos en contextos educativos son la motivación para jugar y el "jugar nuevamente" (Driskell & Dwyer, 1984). Otros autores ha señalado que los factores más importantes para el uso de videojuegos en contextos educativos son el equilibrio entre la facilidad y la dificultad, la atracción de la atención de los aprendices, y la necesidad de diseñar videojuegos en los que los aprendices puedan revisar sus errores (Barnes et al., 2008).

Los videojuegos por computador permiten que el aprendiz genere interés en el proceso de aprendizaje, utilice al máximo sus sentidos, e incluso que construya conocimiento por medio de aplicaciones colaborativas (Vass, 2002). Esto también lo confirman estudios que reconocen que los videojuegos mejoran el desarrollo de ciertas estrategias fundamentales para el aprendizaje: la resolución de problemas, el aprendizaje de secuencias, el razonamiento deductivo y la memorización, simplificando la realización de trabajos en grupo de tipo cooperativo y colaborativo, y el aprendizaje basado en la resolución de tareas (Fernández-Vara & Tan, 2008; McFarlane, 2007). Algunos de estos estudios enfatizan el desarrollo de habilidades de resolución de problemas de competición, de concentración, de movilidad, de lenguaje y de matemáticas (Sánchez, 2008). Algunos educadores se han interesado por los efectos de los videojuegos en los jugadores, y cómo la motivación, por ejemplo, puede se utilizada para facilitar el aprendizaje (Squire, 2003). De esta manera, es posible desarrollar ciertas actividades educativas que promueven el aprendizaje de los aprendices mediante la utilización de videojuegos (Prensky, 2005).

Si bien el uso de videojuegos genera un interés importante en el aprendiz, no necesariamente el aprendizaje que se establece es significativo, dado que no se utilizan metodologías educativas pertinentes. Esto se debe a que los videojuegos no permiten construir conocimiento desde una perspectiva más conceptual si sólo se utilizan de manera aislada al proceso de aprendizaje (Prensky, 2005).

Una de las metodologías educativas que ha tenido un impacto significativo como herramienta de aprendizaje son los mapas conceptuales (Novak, 1984), la cual consiste en la construcción jerárquica conceptual por medio de relaciones conceptuales. Esta técnica permite al aprendiz establecer relaciones con conocimientos previos, bajo condiciones de significatividad lógica, psicológica y una actitud activa y de motivación (Ausubel, 1968; Novak, 1984).

La literatura no describe diseños y desarrollos que involucren el uso de mapas conceptuales en un videojuego educativo. En respuesta a ello, presentamos un estudio que consistió en diseñar, desarrollar y evaluar ConceptGame, un videojuego para generar aprendizaje a través de la construcción de representaciones conceptuales de una disciplina, utilizando la metodología de los mapas conceptuales. De este modo identificamos factores claves de interacción y diseño técnico de herramientas multimediales basadas en videojuegos para que los aprendices construyan mapas conceptuales generando así aprendizajes significativos.

2 Videojuego ConceptGame

2.1 Descripción

ConceptGame es un videojuego educativo tipo Arcade orientado a aprendices entre 9 y 11 años de edad que cursan entre 3ero y 6to año de educación primaria y que tiene como objetivo integrar el uso de la técnica de mapas conceptuales como herramienta de aprendizaje. El videojuego consiste en que el aprendiz debe realizar relaciones semánticas entre conceptos (representados por objetos), los cuales están distribuidos en los distintos escenarios. Estos conceptos son conceptos de ciencias orientados a recursos naturales. La misión del videojuego es encontrar todas las relaciones correctas entre todos estos conceptos.

La estructura del videojuego corresponde a un set de 64 escenarios, distribuidos en una matriz de 8x8 donde el aprendiz realiza las interacciones y navega virtualmente. Cada uno de estos escenarios contiene objetos y obstáculos que el usuario deberá sortear. Los objetos gráficos que son incluidos en los diferentes escenarios en el videojuego fueron confeccionados utilizando contrastes de colores de manera tal de mejorar la visibilidad y la interacción de los usuarios con dichos objetos (ver Figura 3).

2.2 Jugabilidad

Existen 3 situaciones en el videojuego que permiten aumentar la jugabilidad (calidad del juego en términos de sus reglas de funcionamiento y diseño) de ConceptGame:

1. Completitud. El usuario constantemente puede consultar sobre cuánto del mapa conceptual ha sido completado. Esto genera motivación y concentración de las acciones que el usuario ejecuta durante la interacción con ConceptGame.
2. Niveles de Dificultad. A medida que el usuario avanza en las distintas escenas sortea obstáculos representados principalmente por otros personajes que, si logran intersectar al personaje principal, generan que éste pierda el juego. Además, no siempre es fácil alcanzar los distintos niveles de altura para llegar a los objetos que desea conseguir. Debe calcular mentalmente la distancia y los tiempos de acción para la interacción con el personaje principal. Esta situación aumenta la atención en el videojuego, produciendo interés en el usuario por seguir jugando, a pesar de que pierda en el juego.
3. Concentración. El usuario debe leer contenido, extraer información relevante a ese contenido y asociar conceptos. Este es un proceso no trivial e interesante, ya que por una parte permitirá que el usuario avance en el videojuego y por la otra, será el proceso a través del cual tendrá que establecer relaciones conceptuales correctas ayudándole a entender el contenido de aprendizaje.

2.3 Interacción

El videojuego está constituido por distintas interfaces que permiten la interacción del usuario con los distintos elemen-

tos presentes (información del videojuego, gemas, personajes, concepto, opciones de concepto y salida) en cada una de las escenas (ver Figura 1).



Figura 1. Interfaz Principal de ConceptGame

Cada jugador interactúa con las interfaces disponibles, las que entregan información al jugador del estado del juego y el nivel de logro que ha obtenido en un determinado tiempo. El jugador puede obtener información sobre el contenido tratado de manera multimedial (texto, audio y video). Con esta información el jugador crea nuevos enlaces (proposiciones) entre conceptos, todo lo cual alimenta el diseño del mapa conceptual.

Para interactuar con el videojuego se utiliza el teclado y el mouse. El desplazamiento del personaje se realiza por medio de las flechas del teclado. Estos movimientos permiten al personaje saltar por distintos niveles de una escena, tomar gemas y evitar el contacto con los personajes enemigos. En particular, cuando el jugador se posiciona sobre la salida, aparecen las flechas de dirección y a través del mouse del computador se selecciona la dirección a la que desea ser transportado.

El jugador debe pasar por los niveles y obstáculos necesarios para obtener la información que entrega el concepto. Cuando el jugador pasa por sobre un concepto, el videojuego se detiene y presenta sobre él un cuadro informativo multimedial. Para algunos conceptos la información consiste en texto más imágenes y para otros, en texto más un video explicativo del concepto. Aquí también aparecen botones para crear o ver las relaciones que tiene este concepto. Si el jugador selecciona la opción de crear relación, el personaje comenzará a parpadear representando su nuevo estado. Para terminar la relación entre dos conceptos, deberá interceptar otro (aunque sea de otra escena) donde aparecerá un cuadro de selección de relación (ver Figura 2). Aquí el jugador selecciona la palabra enlace que encuentre más representativa entre los dos conceptos y el orden en la relación (A->B ó B->A).



Figura 2. Control para crear relación entre conceptos

El jugador puede terminar el videojuego de tres formas distintas: a) El jugador completa el mapa, teniendo todas las relaciones correctas, b) El jugador fue interceptado por alguno de los personajes "villanos" del videojuego, y c) El tiempo asignado para que el aprendiz termine el mapa culmina. Además, el videojuego presenta gemas de tiempo, que son las encargadas de aumentar el tiempo de juego al jugador. Mientras más gemas, más tiempo tendrá para terminar el mapa completo.

La interfaz del mapa conceptual que el aprendiz arma durante el juego está constituida por una grilla de iconos relacionados y jerarquizados por líneas que los unen. Éstas líneas son las proposiciones que los aprendices deben crear y van apareciendo a medida que el aprendiz completa el mapa (ver Figura 3). Esta interfaz es la que representa el mapa conceptual con los contenidos específicos de ciencia. A medida que el aprendiz interactúa y genera relaciones conceptuales correctas, el mapa provee de una visión general del estado de completitud del videojuego por parte del jugador.

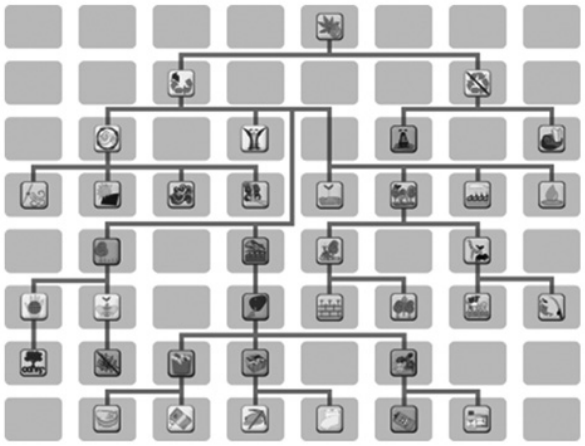


Figura 3. Mapa Conceptual del Videojuego

3 Evaluación de Usabilidad

Con el objetivo de evaluar la usabilidad de ConceptGame se aplicaron dos evaluaciones: 1. Una evaluación preliminar de interfaces de forma cualitativa y cuantitativa con un grupo reducido de usuarios. Esta evaluación tuvo como objetivo principal evaluar la iconografía definida para ConceptGame, observar cómo los aprendices interactúan con las principales interfaces del videojuego y aplicar un cuestionario de satisfacción; 2. Una segunda evaluación de usabilidad del videojuego de carácter cuantitativo (con análisis estadístico) y con un mayor número de usuarios.

3.1 Participantes

Para la primera evaluación los participantes fueron 10 aprendices, 5 niños y 5 niñas con edades entre 9 y 11 años, de la Escuela Básica José Joaquín Prieto Vial de Santiago de Chile y fue realizada en una sesión de 1.5 hrs. En la segunda evaluación participaron 34 usuarios distintos a los primeros con edades entre 9 y 11 años y se realizó en dos sesiones. En la primera sesión participaron 21 aprendices (12 niñas y 9 niños) y en la segunda sesión participaron 13 aprendices (6 niñas y 7 niños). Todos los aprendices pertenecían a la misma Escuela José Joaquín Prieto Vial y fueron seleccionados de manera aleatoria. Ambas evaluaciones fueron ejecutadas por un experto en usabilidad, acompañado de un profesor de computación encargado de ordenar y organizar el proceso, y dar las instrucciones necesarias a los aprendices. El experto se encargó de dirigir la evaluación, observando y haciendo registro de las actividades realizadas.

3.2 Instrumentos

Para la primera evaluación de usabilidad se utilizaron tres instrumentos:

1. Pauta de evaluación de iconos. Consiste en una pauta cualitativa, en donde cada aprendiz, sin ayuda ni información, debió describir qué es lo que entiende por cada uno de los iconos presentados. A cada aprendiz se le mostraron todos los iconos (conceptos) que están en ConceptGame, si el aprendiz no sabía qué significaba alguno de ellos podía dejar la información en blanco o mencionar que no sabía qué era el icono. El total de conceptos asociados a esta evaluación fue 41.
2. Pauta de observación. Con el objetivo de recopilar más datos cualitativos en relación a la interacción de los aprendices con ConceptGame, se realizó una observación no participativa en la cual se observaron las formas de interacción usando el teclado, control y movimiento del personaje y cómo los usuarios identificaron los objetos relevantes en el videojuego. Las tareas que realizaron para esta evaluación corresponden a mini misiones que debían resolver (encontrar una salida en la primera escena, crear una relación en la primera escena entre el contenido preservación y parques nacionales, y ver el video del concepto jabón de la tercera escena).
3. Pauta inicial de satisfacción. Con el objetivo de medir la aceptación de ConceptGame por los aprendices, se aplicó una pauta de evaluación que consta de 7 ítems que debían ser llenados sobre la base de una escala de 1 a 10 (1 es muy mala y 10 es muy buena). Esta pauta corresponde a una adaptación de la Pauta Resumida de Evaluación de Software Educativo (Sánchez, 2003). Las afirmaciones evaluadas por el instrumento hacen referencia a la percepción general del usuario del videojuego ConceptGame. Estas afirmaciones consisten en: “Me gusta el juego”, “El juego es entretenido”, “El juego es desafiante”, “Volvería a jugar con el juego”, “Le mostraría este juego a mis amigos o amigas”, “Aprendí con el software” y “El juego es fácil de usar”. Con esta pauta se evalúa el nivel de satisfacción del aprendiz al interactuar con ConceptGame.

Para la segunda evaluación de usabilidad, se utilizaron 2 instrumentos:

1. Pauta de cotejo de tareas específicas. El objetivo principal de este instrumento fue evaluar cómo se relacionaban las variables edad y género con el cumplimiento de una tarea de búsqueda de un concepto en el videojuego. En la primera tarea definida, los aprendices debían contestar si conocían el significado del concepto conservación y contestar qué es lo que ellos pensaban del significado de ese concepto (tarea 1). Luego, debían buscar este concepto en ConceptGame, leer su significado y luego relacionarlo correctamente con otro concepto en el mismo videojuego (tarea 2). Y la última actividad consistió en que los aprendices debían responder una pregunta de selección múltiple sobre la veracidad de una proposición conceptual que incluía el concepto conservación (tarea 3).
2. Pauta de evaluación de satisfacción de usuarios final. Esta pauta consta de 7 ítems a evaluar por medio de un puntaje de 1 a 10 (similar a la pauta aplicada en la primera evaluación realizada). Además, incluía preguntas abiertas sobre la percepción del videojuego. Esta pauta, al igual que la aplicada en la primera evaluación, evalúa el nivel de satisfacción del aprendiz al interactuar con ConceptGame.

3.3 Procedimiento

La primera evaluación de usabilidad fue realizada en una sesión de 1.5 hrs. Cada aprendiz debía realizar las distintas tareas definidas en orden secuencial. Primero contestaban la evaluación de los iconos, para luego interactuar con el software (resolviendo las tareas asignadas) y luego contestaban la encuesta de satisfacción. La filmación se realizó de manera continua solamente para la etapa de interacción con ConceptGame. Se tomaron fotografías de cada una de las 3 etapas. Sólo la interacción con el videojuego se realizó en un tiempo máximo determinado (10 minutos aproximadamente). El tiempo de las otras dos actividades de llenado de pautas fue variable debido a que los aprendices tenían distintas velocidades de lectura y escritura. Todas estas actividades se realizaron durante el tiempo destinado para la sesión. Para esta evaluación no se identificó si los usuarios cumplían las tareas designadas (esto se realizó en la segunda evaluación de usabilidad), ya que el objetivo fue observar el uso de las interfaces.

La segunda evaluación de usabilidad fue realizada en dos sesiones de 2 horas cada una. Al comienzo de la primera sesión se hizo una introducción a los aprendices sobre qué es lo que se realizaría, señalándoles la importancia de su participación. Se hizo posteriormente una pequeña introducción sobre el concepto de recursos naturales, para que los aprendices entendieran de manera global de qué se trataba el software y sobre qué temas se les preguntaría.

La primera sesión consistió en aplicar la pauta de cotejo de tareas específicas (responder sobre su conocimiento del concepto conservación, interactuar con ConceptGame y responder una pregunta con alternativas). Los 21 aprendices realizaron las tres tareas definidas de forma consecutiva. En la segunda sesión, 13 aprendices interactuaron con ConceptGame durante 20 minutos para luego contestar la pauta de evaluación de satisfacción de usuarios finales.

4 Resultados

La primera evaluación de usabilidad relacionada con la iconografía utilizada da cuenta de lo difícil que es representar conceptos mediante iconografías. La apuesta inicial en el diseño de ConceptGame era que los aprendices podrían identificar rápidamente los conceptos mediante las representaciones gráficas, sin embargo, esta evaluación arrojó que sobre un 95% de los iconos utilizados inducían a error en el significado otorgado por los aprendices. Esto llevó a definir una estrategia de cómo representar los conceptos. Dado que la representación de conceptos más específicos como los tratados en ConceptGame es compleja, se optó por mejorar la representación poniendo una etiqueta con el texto del concepto a cada uno de ellos y refinando su diseño gráfico.

De los resultados obtenidos en la etapa de observación de la primera evaluación de usabilidad se pudo identificar ciertos temas relacionados con la interacción de los aprendices con ConceptGame, esto en conjunto con la revisión de los videos grabados y la definición de patrones comunes de interacción de los aprendices. A continuación se discuten algunos de estos temas.

En los cuadros de información e interacción de los conceptos, los usuarios utilizaron el mouse de manera natural para elegir las opciones disponibles. Esto indica que es una manera rápida de interacción y se debe principalmente a los contrastes de colores que tiene cada cuadro, lo que hace que los botones de interacción se distingan fácilmente, así como también la información de cada concepto (ver Figura 4).

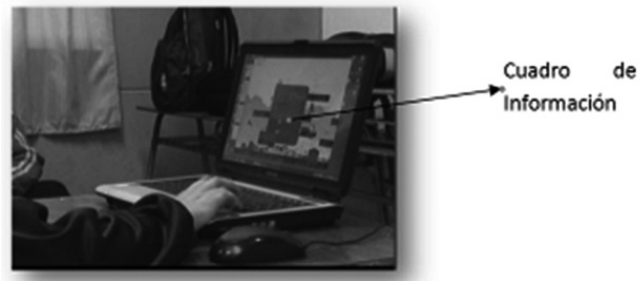


Figura 4. Observación de tarea 1

En general, hubo una insistencia de los usuarios por querer probar nuevamente el videojuego, lo que se notó más en las niñas que en los niños. Cinco aprendices utilizaron la barra espaciadora para saltar y los otros 5 las flechas del teclado. Sin embargo, ninguno de ellos tuvo problemas al desplazar al personaje principal. Se pudo evidenciar además que los niños, a diferencia de las niñas, tienden a explorar más el escenario. Pese a esto, los niños tendían a terminar las tareas primero que las niñas.

De los resultados obtenidos se pudo evidenciar que en promedio, las niñas (8,5 puntos con dStd = 0,6; de un total de 10,0 puntos) entregaron una mejor evaluación de usabilidad de ConceptGame que los niños (6,8 puntos con dStd =3,1; de un total de 10,0 puntos). Este resultado se podría explicar debido a que el videojuego es fácil de utilizar y contiene elementos de interfaz que no tienen relación con un tipo de género en particular (ver Figura 5A).

Los resultados en relación a la usabilidad, considerando la variable edad, nos muestran que los aprendices de 11 años asignaron mayor puntaje a la usabilidad del juego (8,9 puntos) a diferencia de los aprendices de 10 años (6,4 puntos) y los de 9 años (7,5 puntos). Lo importante de estos resultados es que el alto puntaje asignado por los aprendices de 11 años explica que hubo una muy buena aceptación en relación con la interacción del videojuego (ver Figura 5B). Sin embargo, no es posible determinar si hay una linealidad entre resultados de usabilidad y edad (como por ejemplo

que mientras más edad mayor puntaje de usabilidad).

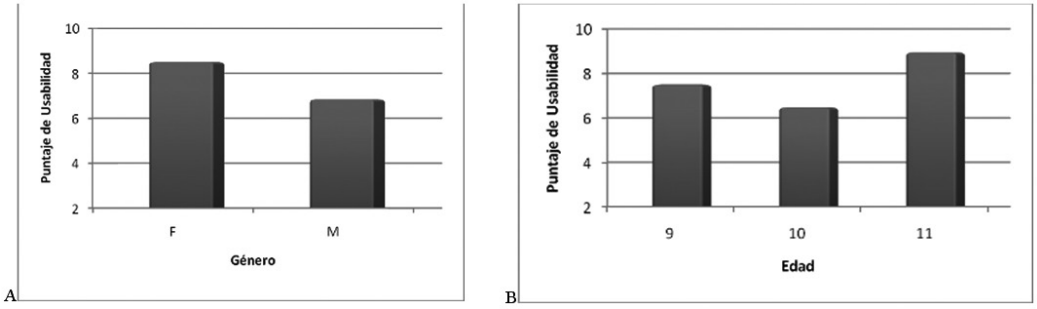


Figura 5. Resultado de usabilidad. (A). Puntaje vs Género. (B). Puntaje vs Edad.

Los resultados en relación a la usabilidad, considerando la variable edad, nos muestran que los aprendices de 11 años asignaron mayor puntaje a la usabilidad del juego (8,9 puntos) a diferencia de los aprendices de 10 años (6,4 puntos) y los de 9 años (7,5 puntos). Lo importante de estos resultados es que el alto puntaje asignado por los aprendices de 11 años explica que hubo una muy buena aceptación en relación con la interacción del videojuego (ver Figura 5B). Sin embargo, no es posible determinar si hay una linealidad entre resultados de usabilidad y edad (como por ejemplo que mientras más edad mayor puntaje de usabilidad).

En relación a la segunda evaluación de usabilidad, los resultados de la tarea 1 (relacionada con la pregunta del significado del concepto conservación), se pudo evidenciar que de los 21 aprendices que participaron en la primera sesión, 12 dieron una definición correcta del concepto de conservación y 9 dieron una definición incorrecta.

Con respecto a la tarea 2, se realizó un test de diferencia de medias, para determinar la relación que existe entre la edad de los aprendices y el cumplimiento de esta tarea. Esto se muestra en la Tabla 1.

Tarea 2	Media	N	Desv. típ.
no cumple	9,55	11	1,036
Cumple	10,10	10	,738
Total	9,81	21	,928

Tabla 1. Análisis de diferencia de medias del cumplimiento de la tarea 2 por edad.

De estos resultados se puede observar que no hubo diferencias significativas entre el cumplimiento de las tareas y la edad de los aprendices, aunque hubo una dispersión menor en el cumplimiento de la tarea en los aprendices de 10 años. En relación al análisis de los datos entre género y el cumplimiento de la tarea, se realizó un análisis descriptivo usando tablas de contingencia (Chi-cuadrado) con el estadístico exacto de Fisher para muestras pequeñas. Los resultados se presentan en las Tablas 2 y 3.

A

			Tarea 2		Total
			no cumple	cumple	
Género	femenino	Recuento	3	6	9
		% de Género	33,3%	66,7%	100,0%
	masculino	Recuento	8	4	12
		% de Género	66,7%	33,3%	100,0%
Total		Recuento	11	10	21
		% de Género	52,4%	47,6%	100,0%

B

	Valor	gl	Sig. asintótica (bilateral)	Sig. exacta (bilateral)	Sig. exacta (unilateral)
Chi-cuadrado de Pearson	2,291(b)	1	,130		
Corrección por continuidad(a)	1,149	1	,284		
Razón de verosimilitudes	2,331	1	,127		
Estadístico exacto de Fisher				,198	,142
N de casos válidos	21				

Tabla 2. Test Estadísticos. A. Tabla de contingencia Género * Tarea. B. Pruebas de chi-cuadrado para significancia estadística

Como se muestra en la Tabla 2, no hubo diferencia significativa entre el género y el cumplimiento de la tarea realizada ($F(1)=0,142;p<0,05$). Esto implica que este tipo de actividades, basadas en relaciones conceptuales, pueden ser utilizadas tanto por niñas como niños. Esto se debe a que la no significancia estadística expresa que no hay relación del cumplimiento de las tareas con el género de los usuarios, lo cual es positivo para nuestro estudio. De los 21 aprendices evaluados (correspondientes al primer grupo) 17 de ellos realizaron la relación correcta sobre el concepto conservación y 4 de manera incorrecta. De estos 4 aprendices 3 pudieron crear una relación coherente después de usar el videojuego. Este último resultado es importante ya que es un acercamiento a que este tipo de aplicaciones basadas en videojuegos podrían explicar de manera lúdica conceptos complejos como los tratados en ConceptGame.

En relación a las pautas de satisfacción, se pudo evidenciar que los aprendices encontraron atractiva la interacción con ConceptGame, otorgándoles buenos puntajes. El ítem que obtuvo menor puntaje fue el correspondiente a la pregunta ¿Es desafiante el juego? (-2.5 puntos en relación a la primera evaluación). Se estima que el resultado en este ítem se debió principalmente a que esta evaluación, a diferencia de la anterior, no tenía un objetivo específico, y a los aprendices se les permitió libre navegación haciendo la actividad menos desafiante.

5 Conclusiones

En este artículo se presenta ConceptGame, un videojuego para generar aprendizaje a través de la construcción de representaciones conceptuales por medio de la técnica de los mapas conceptuales. Se describe el videojuego así como también el proceso de evaluación de usabilidad. Este videojuego fue desarrollado para apoyar los procesos de representación conceptual en aprendices entre 9 y 11 años de edad. Se realizó una evaluación preliminar de interfaces y un testeo de usabilidad más profundo. Asimismo, se realizó análisis cuantitativo y cualitativo de los testeos realizados. Cada uno de los testeos implicó una serie de modificaciones (rediseño) al videojuego desarrollado.

Un efecto importante rescatado de la primera evaluación corresponde a que se observó y registró que las niñas tenían un nivel de satisfacción en la interacción mayor que los niños. Lo importante de este resultado es que indica que puede ser motivador su utilización por aprendices, independiente de su género, así como también se evidenció que la interacción con el teclado era fácil, ya que los aprendices sin previa instrucción comenzaban a jugar sin problemas.

De la segunda evaluación se puede inferir que los cambios realizados mejoraron aspectos técnicos de ConceptGame, como la visibilidad, el entendimiento de los conceptos tratados y la ubicación espacial de los objetos con la finalidad de facilitar la interacción del usuario con el videojuego. En relación a los datos estadísticos obtenidos por el test de diferencias de medias en la segunda evaluación, se evidenció que no hubo diferencias significativas entre quiénes cumplían la tarea, aunque hubo una dispersión menor en los aprendices de 10 años a diferencia de los de 9 años. Esto permite que ConceptGame pueda ser utilizado sin problemas por los aprendices de ambas edades. La aplicación del test estadístico exacto de Fisher permitió deducir que no existe significancia estadística entre el género de los participantes y el cumplimiento de las tareas determinadas. En este estudio la no significancia estadística es un buen resultado ya que nos indica que tanto niñas como niños pueden utilizar ConceptGame sin diferencia entre ellos.

Finalmente, este estudio se concentró principalmente en las interfaces del videojuego, sin embargo, se propone realizar un segundo estudio experimental, más sistemático y de mayor extensión en la intervención, para evaluar cómo afecta el uso de este videojuego en el aprendizaje de los aprendices. Esto permitiría definir claramente la importancia y el real impacto del uso de este tipo de videojuegos como recurso educativo para fines de aprendizaje.

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CONCEPT MAP AS SCHOOL GENRE: CONSIDERATIONS FOR TEACHING AND LEARNING

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Abstract. This paper aims at reflecting upon concept maps teaching and learning in school. Firstly it assumes Bakhtin's theory on language, and genres, as an attempt to help people understand the complexity of a language process such as the one involved in concept map production, and, at the same time, what it means to consider a text a specific genre. Bronckart's theory of genre is referred and paralleled to Novak and Cañas' description of concept map as a way of analyzing the genre. Then, based on Dolz e Schneuwly it situates the concept map in the context of school, assuming it a school genre, which would be the first step into being able to design a teaching sequence for the concept map. It stands as a motivation for language teachers to work together with computer science teachers and specific discipline teachers as ways of helping students develop progressively the communicative skills which production of meaning in concept map involve.

1 Introduction

The use of concept map has been growing. Proposed in the 70´s by Novak when facing difficulty in organizing and representing knowledge and more recently digitalized by Cañas through the Cmap tools, it has been being used in education as a teaching and learning tool. Research can be found which show the benefits of using the tool specially linked to meaningful learning. Research which analyze it as a text genre are scarce though, even in the linguistics field, which would help in considerations on how to teach it as a genre. We are all native speakers of one idiom or another, that does not qualify everyone to teach such idiom, does it? We can read, and that does not qualify us to be elementary school teachers teaching literacy, does it? The point is: we may be good concept map readers or producers, is that enough to be good reading and producing cmaps teachers? Usually not.

This paper discusses theoretical issues concerning concept maps from the point of view linguistics, more specifically, from the socio-interactionist approach. Assuming concept map as a genre of discourse, and furthermore, as a school genre, it aims at reinforcing teacher's awareness of the need to consider the linguistic dimension to be able to propose meaningful activities involving concept maps.

2 Concept maps as a genre

According to Bakhtin(2002), the history of society is linked to the history of language transformations which are reflected in genres. That is to say that the different historical moments and contexts are marked and determined by genres that come and genres that disappear or are transformed.

"The use of language happens in the form of utterance (oral or written), concrete and unique, which emanate from one or another sphere of human activity. A utterance reflects the specific conditions and purposes of each of such spheres, not only for its content (theme) and its verbal style, that is, for the operated selection of language resources – lexical, phrasal and grammar resources, but yet, and most, for its compositional structure" (Bahktin 1975 p. 279).

According to the author, these three elements – theme content, style and compositional construction – cast in the whole of the statement and are marked by the specificity of a sphere of communication. Each sphere elaborates its relatively stable types of statements, such types Bakhtin calls genres of discourse. The author states that no one can ignore the nature of the utterance and particularities of the genre in a linguistic study.

A concept map is a specific genre, it uses language to communicate utterances. Studies involving concept maps are linguistic studies too and should be considered as so. A concept map has a content theme, has a style and a com-

positional structure, which should be considered in the production of meaning which designing or reading it aims at.

According to Bakhtin, genres are dynamic. They are born and die or disappear – many times related to technological advances or scientific evolution. Examples are the wide spread of e-mails and social networks, and the fall of telegraph. The genre concept map is recent, given its possibilities, not very much used. The Cmap tools makes a revolution possible in terms of knowledge accessing and it is making the concept map more popular. But still, being innovative, it will have to face the resistance of the movements of conservation of society.

According to Novak & Cañas

"Concept maps are graphical tools for organizing and representing knowledge. They include concepts, usually enclosed in circles or boxes of some type, and relationships between concepts indicated by a connecting line linking two concepts. Words on the line, referred to as linking words or linking phrases, specify the relationship between the two concepts. We define concept as a perceived regularity in events or objects, or records of events or objects, designated by a label. The label for most concepts is a word, although sometimes we use symbols such as + or %, and sometimes more than one word is used. Propositions are statements about some object or event in the universe, either naturally occurring or constructed. Propositions contain two or more concepts connected using linking words or phrases to form a meaningful statement. Sometimes these are called semantic units, or units of meaning." (Novak and Cañas, 2008)

Concept map is a map of concepts and their relations. Such concepts are here considered in Bahktin's perspective of the notion of word. The notion of word is central to Bakhtin's theory. Stella (2005) states that, for Bakhtin., the word is faced as a concrete element of ideological making, related to the life, to the reality.

"The speaker, giving life to a word with his intonation, dialogues directly with the values of society, expressing his points of views in relation to such values. These such values must be apprehended and confirmed or not buy the interlocutor. The spoken, expressed, stated word constitutes itself in a ideological product, result of a interaction process in live reality." (Stella 2005 p.178)

Bakhtin states that the word, as the phrase, cannot be considered isolated, for it would have meaning, but would not have sense. Meaning refers to the elements of utterance which are reiterable and identical every time they are repeated. They are abstract elements founded upon a convention and have no concrete existence. The theme is the expression of a concrete historical situation which originated the utterance. The theme of the utterance is not reducible to analysis. Meaning, on the other hand, according to Bakhtin, can be analyzed in a set of significances linked to the linguistic elements that compose it. Meaning is not anything in itself; it is, according to this perspective, just a potential, a possibility of sense in a concrete theme .

To Bakhtin, the lexicographical meanings of word of a language guarantee their common use and comprehension by the speakers of the language, but as they are used in active verbal communication, they will always be marked by individuality and by the context.

"One can state that a word exists to the interlocutor under three aspects: as a neutral word in a language that does not belong to anyone; as word of another, pertaining to other and which fill the echoes of other people's utterances; and, finally, as my word, for, as I use this word in a specific situation, with a discursive intention, it has already been impregnated with my expressivity. (Bakhtin, 1992, p.313)

The neutral word would be that which presents a potential meaning that makes it possible for it to be used in many different contexts, in different utterance situations. The word of another and my word are marked by expressivity , which does not belong to the word (neutral) itself: belongs to the other and to me. The distinction between my word and the word of another is complex. According to Bakhtin, "the time, the social environment, the micro-cosmos – of the family, of the friends, of the colleagues – that sees man grow and live always possesses its own utterances, which work as norm and give the tone" (1992, p 313). The tone come from scientific, literary and ideological works in which people rely making references, and quoting them.

"The tone comes from followed traditions that express themselves and preserve themselves in the involucrus of words. There are always a certain number of directions that emanate from the lights of a time, certain number of objectives to be pursued, a certain number of words of order, etc " (Bakhtin, 1992, p.313)

Bakhtin states that our discourse is full of words of another, therefore, he points out that only a mythical Adam would intend to use a word for the first time and therefore, not bring in it, the marks of the others – marks of expressivity that we assimilate, restructure, modify, leaving our own mark and making them my word.

According to this author, therefore, other voices are present in each discourse, but these voices do not work in the same way: there voices that are persuasive and voices that are authoritarian.

"The word of another presents itself not as information, rules, models ,etc. It tries to define its own basis to our ideological attitude in relation to the world and to our behavior, it appears here as authoritarian and as interiorly persuasive" (p.142).

To Bakhtin, finally, words carry their marks of social and historical life, they are not available neutral of ideology, nevertheless, the enunciator has the challenge of using them, pronouncing himself dialogically in order to answer and generate questions; adding to these same words his individuality. Concerning this aspect, Bakhtin states that "the word of a language is a half other people's word, it only becomes own when the speaker populates it with his intention, with his accent, when he dominates it with his discourse, making it familiar with his semantic and expressive orientation."(p.100). One can say that there is a code, but this code is used by many languages, at each new utterance, another language, for language must involve meaning, and sense only happens in context.

To be an author to Bakhtin is to assume a strategic position in context of circulation and in the battle of voices. Authorship is not the same as singularity, the subject may not assume a strategic position in the dialogical current, he may not have a dialogic attitude, that would arise or answer questions, he may assume a monologic position, when, for example, he makes utterances just by using authoritarian words. Every enunciative act is fundamentally dialogic but it can be more open or more close, more authentic or more usual.

Bakhtin states that every discourse shows monologic and dialogic movements, they act in the infinite dynamic of human evolution, he relates such movements as the centrifugal and centripetal forces. In the infinite historic-ideological chain, although evolution is constant, there are moments of more approximation of ideological currents, moments of more or silence, when there seems to be monologization. The centrifugal force subverts the tendency to monologization, it maintains the dialogical current alive. The phenomenon of the forces can be treated in the macro historical level of the evolution of human knowledge, but it can also be evidenced in the micro, at each enunciative act.

The theory proposed by Bakhtin is vast and not simple to grasp. The intention here was not, in any way, to attempt at providing a comprehensive explanation of it, but pointing out some important ideas for the scope of this paper and arise the readers interest in Bakhtin. As for the concept map, what is to be stressed is:

- a concept map is a genre, therefore, being marked by the broad historical context in which it exists;
- concept maps have compositional structures, the production or understanding of which involve communicative abilities that need to be developed; a school, a language class, would be a good place to do that as is happens with other genres;
- a concept, considered as a word, has meaning but does not have sense if not considered in the context of a utterance;
- the concept's context is a concept map, and a concept map is a utterance which will have no sense if not considered in the micro and macro context of production;
- A concept map is made of words, own words and another's word, identifying which is which is a complex task even to the producer;
- teaching is a complex language process, teachers teach words of another, referring to theories for example, doing it they mark it with their own words, and they should ideally do that in a way of encourage students own words to have authorship - being conscious of this is fundamental for a teacher to understand the complexity of the process he has to carry through;
- in discourse, there are movements of centralization and of decentralization; they are always present together but not in the same intensity; a word, a single concept, should be taught and learned never as closed or authority;
- in a concept map, such movements will be present as well.

Bakhtin, however, does not propose principles that can be followed to characterized a genre, that was not his

intent. Discourse analysis that relies in Bakhtin need to retrieve to textual theories that comply with Bakhtin's philosophy of language and that makes it possible for the characterization of a genre, such as Concept Map. We assume Jean Paul Bronckart's theory as adequate for that matter and will attempt at applying it to concept maps. By doing so we will present a theory of text, or genre, and then consider the concept map from that point of view.

3 The textual layers of Bronckart

Bronckart's approach sets from the theory of social interactionism, according to which "the specific properties of human conducts constitute the result of a historical process of socialization, made possible, mainly, through the emergency and development of semiotic tools" (Bronckart, 1999, p.21). He points out that socio-discursive interactionism is based in the capacity human beings have of interacting with the environment and of preserving their psychological traits in the context of collective activities. This theory posts that man can create instruments that mediate his relation with the environment and organize forms of cooperation at work, giving birth to social formations and development of linguistic forms of exchange with his congeners.

To Bronckart, text designates "every unity of production which diffuse a linguistically organized message and that tends to produce an effect of coherence in the addressee" (p.71). According to this author, the texts is articulated to the needs, to the interests and to the conditions of functioning of the social formations at the heart of which they are produced. He states that "as the social contexts are so diverse and evolutive , consequently, in the course of history, in the frame of each verbal communication, different ways of producing a text, or different text species emerged. The author assumes the terminology text genre to refer to such different species of texts.

What happens, as Bronckart points out, is that a same text can be composed by many different segments. A scientific paper for instance can be composed by a main segment of theoretical exposition and by interpolated segments of chronological accounts on the constitution of the concurring theories. In novels this is even more evident for there are segments where the chronology of the actions are taking place and interpolations of segments that introduce the characters dialogues and commentaries of the author. Bronckart suggests that only at the level of such specific segments that one can perform a classification with linguistic criteria. The genres are of infinite number, but the segments are not, and can be at least partially identified for its specific linguistic characteristics. Such segments he calls discourses and can be designated by type of discourse.

"The situation of verbal communication of a verbal agent is, at least in part, new or particular and this singularity leads him to organize in a certain way the types of discourse that constitute his text and to use, in a more or less original way, the linguistic resources of the types. That way, although every text is elaborated with reference to the social models of the genres and the types , they are also characterized by particular modalities of applying such models, which derive from the particular representation that the agent has of the situation in which he is in" (p.76)

According to him, for singular or empirical text one must understand a concrete unity of language production, pertaining to a genre, composed by types of discourse, but which also presents the traits of the decisions made by the individual producer in function of his own particular situation.

The conceptual apparel proposed by Bronckart for the analysis of the internal organization of a text is set from the general hypothesis that every text is organized in three superimposed layers, which he defines as textual layers. The three layers are: general infrastructure of the text, textualization mechanisms and enunciatory mechanisms.

The infrastructure is the deepest level, it is constituted by the broader plan of the text, by the types of discourse and by the sequences in which they appear. The general plan refers to the organization of the thematic content, it may assume many forms, for it depends on the genre and the number of genre are unlimited. It varies specially because of the combination of different types of discourse , of the sequences and the forms of planification that appear in the text. For type of discourse Bronckart designates the linguistic forms that translate the creation of specific discursive worlds, the different segments that the text comprises, he proposes that analysis through different forms of articulation, enchainment or fusion between such discourses.

Bronckart proposes four discursive worlds based in the opposition between to narrate and to expose and between implication and autonomy. According to him, when put in the narrative order , the discursive world is situated "somewhere else", that must, however, remain as a similar world, possible of evaluation and interpretation by the

interpreter of the text. Once situated at distance and similar, such worlds may present different deviation in relation to the ordinary world. According to such deviation, the author proposes the distinction between realistic narrative and fictional narrative. In the worlds situated in the order of exposure, on the other hand, the theme content is always, by principle, interpreted according to the criteria of validity of the ordinary world which would be the case for concept maps for they are used in the order of exposure, not narrative.

Another opposition he proposes is explained through the explicitness or not of the relations that the instances of agentivity maintain with the material parameters of the language action. If a text mobilizes the parameters of the language action, this text is implicated and in order to interpret it one must appeal to the conditions of production. A text will be, on the other hand, autonomous if it presents autonomy in relation to the parameters of actions of language and its interpretation does not require appealing to conditions of production. A concept map would, according to this point of view, be situated in the autonomous world of exposure for it is intended to be self-explainable, that is, when it is produced, the intention of the author is that the reader, the interpreter, would be able to make sense of it not having to resource to the author and the context of production for understanding.

The discursive sequences, according to Bronckart designate the form of planification that take place in the interior of the general plan of the text. He assumes Adam's five proposed sequences: narrative, descriptive, argumentative, explicative and dialogical. The narrative plan presents initial situation, complication, actions, resolutions, final situation, evaluation and moral. The argumentative sequence presents a prototype of a succession of four phases: the phase of assumption, phase of presentation of argument, phase of presentation of counter arguments and phase of conclusions, or of new thesis. To the sequence of explanation he proposes also four stages: initial verification, problematization, resolution and evaluation-conclusion. The dialogical sequence has the opening phase, transitional phase and closing phase. The descriptive sequence is not organized in a linear way, but is put together in a hierarchical or vertical way. This sequence presents prototypically, anchorage stage , when the sequence's theme is presented , aspectualization stage, in which the theme title is decomposed in parts to which properties are attributed and relation stage in which described elements are assimilated to others by comparison or metaphor. Considering Novak and Cañas's description of concept map as graphical tools for organizing and representing knowledge composed through concepts and propositions involving them, designed in a structure that follows some kind of hierarchical organization, the descriptive sequence would be the one most common in a concept map.

Bronckart highlights, however, that such phases are not in any way rigid, they have regularity which can be identified and they are proposed from this regularity.

The second layer proposed by Bronckart is constituted by mechanisms of textualization. Mechanisms of textualization, according t the author, create isotopic series that help the establishment of thematic coherence. They explicit the hierarchic , logic and temporal articulations of the text. They can be grouped in three big sets: connection, nominal cohesion and verbal cohesion.

The mechanisms of connection mark the articulations of thematic progression and are performed by textual organizers. As for mechanisms of textualization in a concept map its iconic or imagistic design which use linking lines between concepts and the propositions they compose conform its most evident attempt to cohesion. The lines and the concepts they connect form the unit, the textual unity of the concept map. They are part of the design which make it visually a text of this specific genre. In essays or other form of linear narrative texts, conjunctions, adverbs and prepositional sintagms work as linking elements.

Mechanisms of nominal cohesion introduce the themes and/or new characters and guarantee the retaking or substitution in the development of the text. In this case, such mechanisms may be personal , demonstrative, possessive, relative pronouns or nominal sintagms. Mechanisms of nominal cohesion work to organize or make clear in the text whom, or what it is referring to, or "talking" about. In a concept map we usually don't find pronouns; pronouns appear referring to other nouns previously mentioned, in a map of concepts such role is played by the linking lines; pronouns may appear as linking words, but not as a concept in itself. In an essay, for instance, about volcanos, we would find pronouns such as it, this just so not to repeat the concept volcano while trying to again and again refer to the subject of matter. In a concept map, the concept volcano can be linked to many different concepts and does not appear repeated in the map.

The mechanisms of verbal cohesion guarantee the temporal or hierarchical organization of the process – states, occurrences or actions – verbalized in the text and are performed by the verbal time, which appear with other units of temporal value. Verbs and prepositions are usually the most used elements used to form the propositions that connect concepts.

The third layer is constituted by the enunciative mechanisms which are responsible for the pragmatic coherence of the text. So they contribute to the clarifying of the enunciative positions and translate the evaluation of aspects of the thematic content.

Bronckart states that if we were to assume the notion of author as the agent of language who concretizes himself in an empirical text, it would be him who decides about the thematic content, who chooses a genre model suited to his situation of communication, who selects and organizes the types of discourses, who manages the diverse mechanisms of textualization.

"When undertaking a language action, the author mobilizes, from the vast set of knowledge from which it seats, representational subsets that refer specially to the physical and social context of his intervention, to the thematic that will be mobilized be the actions and it and to his own statute of agent (action capacities, intentions, motivations). As all human knowledge, theses representations are constructed in interactions with the actions and discourse of others, and even when they are the target to a singular organization, which results from the experiential dimension of each person, they still port the traits of this constitutive alterity. Whether they are notions, opinions, or values, the representations available in the author are always already interactive, in the sense that they integrate others' representations, in the sense that they continue to confront and deal with them" (p.321).

According to Bronckart, as it is for Bakhtin, in order to attribute responsibility of the text, it is necessary to recognize that the representations activated have social character, that is, they are a dialogical dimension. When producing a text, in this theory, the author creates discursive worlds whose coordenates and rules are different from the ones of the empirical world in which he is insered; it is from such virtual worlds and from the distances that guide them that the voices that are expressed in the text are distributed and orchestred and are responsible for the evaluations performed in it. The voices are, therefore, entities that take up the responsibility of what is being enunciated.

The voices that express themselves in a text can be grouped in three subsets: the voice of the empirical author, the social voices and the voice of the characters. The voice of the author is the voice that comes from the person who is in the origin of the textual production and intervenes to comment or evaluate what is enunciated. The social voice is the voice that come from the characters, groups or social institutions which are mentioned as external instances of evaluation of content aspects. The characters voices, finally, are the voices of the human beings implicated in the happenings or constitutive actions of the thematic content of a segment of a text. Bronckart points out, however, that such voices can be implicit, not being translated through linguistic forms, or they may be explicit through the use of pronominal forms, nominal sintagms, for example.

The understanding of the "orchestra" of voices in a text, in a concept map, is very important for a project of education that involves the critical dimension.

Neither the presentation on Bakhtin's or Bronckart's theory had here the pretension of being comprehensive. In the context of this paper, the objective was to set light at what it means to produce or read a text, specifically here, a concept map.

According to Novak, new knowledge constructed by observing events or objects through the concepts we already posses. He defines event as anything that happens or can be made to happen, and object as anything that exists and can be observed, being them natural or human constructed. A concept is a regularity in events or objects designated by some label. Such label they call "word". Concept maps, as Novak and Cañas define it, are graphical tools for organizing and representing knowledge. Concept maps, according to them, include concepts and relationships between concepts, shown through linking words or phrases, called "propositions". Concept maps should be hierarchical, more general, inclusive concepts at the top, with progressively more specific, less inclusive arranged below them. Concept and propositions form units of meaning. Concept map is language. It is a text.

4 Concept map as school genre

To produce and to understand texts, as we have pointed out, is not a simple activity of codification and decodification, but a complex process of production of meaning in face of inferential activities. A text is a proposal of meaning and it is only complete with the participation of the reader/listener. A text, therefore, is not an object, a product, but an event and its existence depends on someone producing it in a context. It is a discoursive fact, not a language system fact. It occurs in the enunciative activity not as a simple relation of signs.

Assuming language as cognitive activity or just a system of representation, one can incur in a risk of reductionism, which confines language to its exclusive condition of mental phenomenon and system of conceptual representation. Language involves cognitive activities, but it is not a phenomenon just cognitive.

A text is not defined through necessary and sufficient eminent properties, but for being situated in a socio-interactive context and for fulfilling a set of conditions which conduce cognitively to the production of meaning. The sequence of linguistic elements will be a text as it is able to offer interpretive access to an individual that has a communicative experience relevant to comprehension.

The difficulties of students in producing meaning in reading and writing and therefore the development of the communicative or language proficiencies related to it have been a great concern to language teachers. However, if the role of school education is to enable the students to use language as instrument of learning by being able to make sense of the information it presents, as well as to analyze critically such language as vehicle of values and ideologies, and to grasp its sometimes opaque intentionality, then the development of such skills is the responsibility of any teacher in school for they all teach for and through language.

In Brazil, such responsibility is made clear in the national standards for basic education (PCN, 1997,p.30) in which it is stated that is school's responsibility to make the access to the universe of text that circulate socially possible for the student, teaching their production and interpretation. This includes texts of different disciplines, with which the student is faced in school context and, even so, is not able to handle, for there is not a systematic and planned teaching project with this objective.

A number of theoretician have been dedicating themselves to the study of the school genres, among whom, Dolz e Schneuwly (1996). According to these authors, school has always worked with genres, for the communication used in learning is crystallized in genres. The authors point out that in school there is a unfolding of such work because the genre is a mean of communication and an object of study in itself. Do to that, the genre, at school, institutes a language practice that is, in part, fictitious for it is instituted with learning purposes.

To Dolz and Shneulwy the teaching and learning of genres leads to a transformation of them for they will have to be simplified and/or to receive certain emphasis so that they can be "dominated" by the learners, besides being used in a different social place. The authors point out that the proposition of a genre in school is the result of a didactic decision which aims at learning objectives that can be of two kinds: learn to dominate the genre first to better know it or appreciate it to better know how to understand it, to better produce it inside or outside school; secondly to develop capacities that go beyond the genre and that can be transferred to other genres. This implies a transformation of the genre so that such objectives are reached or reachable with most efficiency.

A genre in school is, therefore, a genre to be learned although it will still be a genre to communicate. Ideally teachers should provide students with situations that are the closest possible to real communicative situations. To the authors, a didactic model for teaching and learning a genre should explicit the implicit knowledge of a genre, referring to the formulated knowledge, in the domain of scientific research as well as by experts in the area. It should also consider its pertinence in reference to the students' abilities, school objectives and teaching and learning purposes, and it should make the contents coherent in relation to the objectives aimed at.

A didactic model, in synthesis, has two great characteristics according to the authors: it is synthesis of a practical objective, destined to guide the teachers' interventions; and it makes evident the teaching dimensions from which different didactic sequences can be designed. The authors point out that in each of such dimensions a progression is possible.

The authors state that the more a precise definition of the teaching dimensions of a genre , the more it will facilitate the appropriation of it as instrument and will make the development of diverse language capacities associated to it possible.

Texts in schools are, therefore, every teacher's business. Texts need to be instruments and object of educational projects in school. The skills involved in the production of meaning in texts are developed through didactic projects, planned for that matter.

A concept map is a text, if it is to be proposed in school for educational means, it needs to be treated as a school genre, becoming an object of study in itself.

This may seem obvious, and simple, but, unfortunately, especially for teachers of areas other than language, it is not. Teachers sometimes take for granted the complexity of the genres they are teaching and evaluating through.

As for how to propose a genre approach in the elaboration of a didactic sequence, Bronckart(1999) suggests an activity in four stages:

(I) Elaboration of a didactic model: choosing a genre and its adaptation to what the students know, then analyze the properties of such genre, its uses its forms of realization, its variations and it context of uses.

a. analyze the discursive activities: learn the criteria for choosing a genre in a specific situation of communication, simulate the position of a genre producer imagining the intentions on the interlocutors (receptor, etc) identify the knowledge to be mobilized to produce the genre in the situation imagined, specify the communicative structures and the conventional form that the genre presents;

b. operate with the typical sequences: knowing how to coordinate the sequences that are needed to compose the textual based coherence, as the argumentative, narrative and expositive sequences;

c. dominate the linguistic mechanisms, study and analyze syntatic, morphologic and lexical properties as choice of register and style, textual organization under the aspects of cohesion and coherence.

(II) identifying the acquired capacities

Testing the students, checking if they understood the capacities related to discursive actions, tipological actions and textual-linguistic actions;

(III) elaborate and conduce activities of production once the capacities have been identified in relation to the chosen genre , propose effective exercises of production, offering specific conditions and situations according to the elements analyzed in I and II;

(IV) Evaluate the acquired capacities: analyze the productions giving them appropriate feedback

The main idea is that real situations have to be created with contexts that allow reproducing in big guide lines and in detail the concrete situation of textual production including its circulation, that is, with special care to the process of relation between producers and receivers/ receptors.

According to Novak's(1984) approach, the first step is to elaborate a good focus question. Every map answers a focus question. Now, who posts the question? Make sure the question is appropriate, that it is a product of the context as Bakhtin puts it. Questions should be natural, not imposed. Postman (1978) says that teachers should not ask questions they know the answers to, students should be asking the questions. So let the question emerge from the context – the students, the class situation, the external situations they may bring to class, etc. In Bakhtin's point of view: let them be the authors of the focus question.

Once the focus question is defined, next step, according to Novak, is identifying the key-concepts which apply to the domain of the question. At this point it is fundamental that the students understand the concept of concept. The concept of the word concept has been a historical issue in episthemology studies. To Novak, a concept, is a regularity in objects or event designated by some label. This regularity changes in time, concepts have not always designated the same thing, regularities have been designated using different labels. Furthermore, a concept is a word, a word of whom? When a student pronounces a word, whose word is that? The teacher's? The theorical the teacher read and assumed? When he makes that word choice whom does he give voice to? Ideologically who speaks? When the teacher speaks, the same questions can be posed. Again, it is a complex process.

One can follow Novak and Cañas orientation on how to produce maps, guideline on teaching are fully presented in Novak's Learning how to learn(1984), but do so assuming concept map as a text and, as text, assume the complexity of the language process that undergoes when producing a map or any text for that matter.

Making a map is a complex ability that cannot be taken for granted. Teaching it too. Concept maps seem to be concern more of science teachers. That may be due to its characteristics for they seem more suitable for explaining and to describing as Novak and Cañas state "events and concepts" than to narrating actions. As they are dependable on linguistic abilities either for reading or writing them, they should be language teachers concern as well.

Communicative abilities development have been an issue in schools; specific area teachers say that the students can't write, and language teachers say that the students lack what to write about. What happens, at least in Brazil, is that teachers work separately. The language teacher may ask them to write about something that involves specific area content, and grades the papers more for the form than for the content, which they are not really proficient at. The content teachers, science, for example, ask students to write texts assuming they know the form, they grade mostly over the specific area content. Sometimes the problem may not be not knowing the content, but not knowing how to write a good text.

Concept maps are very appropriate for cooperative teaching projects involving the language teacher and the specific area teacher. And if Cmap tools is accessible, even the computer science teacher, who is many times, in Brazil, asking students to produce texts on whatever content just so they learns the digital tools, and that is what he evaluates – which is a waste in terms of everything that was involved in the process of such production.

Teachers teach or aim at enhancing meaningful learning in students. They work with concepts, all areas work with concepts. Concepts are words. Every teacher not only teaches using language, but teaches language as well. Any teacher, therefore, must have a linguistic understanding of his role as concept, or language, teacher. A language teacher is someone whose project involves teaching the communicative abilities that make performance in specific areas, or different social contexts potentially successful. But he will never be able to work with language and not with concepts, events, ideas that relate to different areas of knowledge.

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CONCEPTUAL MAPPING TO FACILITATE REVIEW OF STATE SCIENCE STANDARDS

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Abstract. The Massachusetts Science and Technology/Engineering Curriculum Framework (MA ESE, 2001/2006) establishes the standards for grades PreK-12. In 2008-2009, the MA Department of Elementary and Secondary Education set out to produce strand maps of the state science standards, modeled on the American Association for the Advancement of Science (AAAS) Atlases for Scientific Literacy (AAAS, 2001, 2007) to facilitate the review and revision of those standards. CmapTools was used for the initial production of these state science strand maps. Strand maps illustrate the progression of science concepts and skills across the PreK-12 span. The strand maps revealed three major features of the current state framework: 1) standards with varying levels of conceptual support across the entire PreK-12 span; 2) recurring patterns of relationships among standards; and 3) varying levels of specificity among standards. In particular, the strand maps revealed standards that were not conceptually supported in early grades, "opportunity-to learn-gaps" in which standards for a topic were at early and late grades but without concepts bridging those years, and some standards that were simply isolated from other standards. Patterns of relationships among standards included diverging and converging concepts and crosslinking within and among topics and strands. Understanding these features is key to revising state standards to enhance progressions of learning across grade spans to make explicit conceptual relationships across grade spans. State standards revised into strand maps offer a foundation to integrate efforts across the educational community that target meaningful learning.

1 Introduction

The first AAAS Project 2061 publication, Science for All Americans (AAAS, 1989), set out to define science literacy and lay out some principles for effective learning and teaching. This was quickly followed by Benchmarks for Science Literacy (AAAS, 1993), specifying how students should progress toward science literacy, recommending what they should know and be able to do by the time they reach grade levels 2, 5, 8, and 12. The Atlases of Science Literacy (AAAS, 2001, 2007) transformed the benchmarks into strand maps that demonstrated how the most important ideas of science fit together and develop across the K-12 grade spans. Each strand map focuses on a topic important for literacy in science, mathematics, and technology and displays the benchmarks across the K-12 span that are most relevant to understanding it. For each benchmark, there is a suggestion of earlier benchmarks upon which it builds and later benchmarks that it supports, thus highlighting the developmental nature of the topic. With these maps as a model, the authors of this paper worked to create strand maps of the current Massachusetts Science and Technology/Engineering standards, to observe patterns revealed by those strand maps, to present standards in a visual format that highlights conceptual relationships, and to suggest how these maps may contribute to the science standards review process and to concept mapping efforts within the broader educational community.

2 The Science Standards Review Process

Massachusetts has been working to incorporate a learning progression perspective in state science standards through the current revision process. Massachusetts' science standards currently put a strong emphasis on content knowledge; the standards are organized around four strands of science at grades PreK-8 (earth and space science, life science, physical science, and technology/engineering) and five "introductory" high school courses (earth and space science, biology, chemistry, physics, and technology/engineering). The first set of Massachusetts' science standards was completed in 1993, with a full revision in 2001, a partial revision in 2006, and now a second full revision underway (expected completion in 2011). (The MA Science and Technology/Engineering Curriculum Framework is available at: http://www.doe.mass.edu/frameworks/current.html). The process for revising state science standards includes assembling a revision panel of volunteer members that are representative of the state's science education community (including

practitioners, higher education faculty, and organizational/community membership); identifying and referencing national science standards and assessment documents; drafting and redrafting standards based on research and panelist expertise; and gathering significant public input on those drafts.

The goal of the current review of the state's science standards is to use the revision process to explicitly and systematically draw upon educational research, including available learning progression research (NRC, 2007; Corcorcan et al, 2009), to assure effective support for student learning of key science concepts and skills across time. This paper shows how the development and use of strand maps supports the standards revision by making visible student learning over time and making explicit the connections between topics and disciplines.

3 Strand Maps: Representation of Progressions of Learning

The current Massachusetts science strand maps (available at http://www.doe.mass.edu/omste/maps/) show how students' understanding of ideas and skills that lead to scientific and technological literacy might develop over time from PreK to high school. The Atlas for Science Literacy strand maps (available at http://strandmaps.nsdl.org/) were used as a model for the Commonwealth's strand maps. All Figures in this paper are examples taken from the Massachusetts strand maps. Clear text and color-coding can be viewed via Internet. Each cell of the strand map is an actual state science standard. The arrows between cells represent conceptual (not curricular) relationships between concepts. CmapTools was used to create these maps.

The strand maps enable educators to see how the knowledge and skills students learn in different grades depend on and support one another. Thus, strand maps represent a progression of learning. For example, Figure 1 presents a portion of the Physical Science strand map on force and motion. Foundations of understandings about the motion of objects and their relationship to force are established at the PreK-2 level. Students are expected to 1) demonstrate that the way to change the motion of an object is to apply a force and 2) describe the various ways that objects can move. In Grades 6-8, students are expected to develop ideas of motion further to explain and give examples of how the motion of an object can be described by its position, direction of motion, and speed. (Note there are additional standards on force, not included here). By high school students are expected to construct an even more technical conception of motion and be able to compare and contrast vector and scalar quantities and distinguish between and solve problems involving displacement, distance, velocity, speed and acceleration.

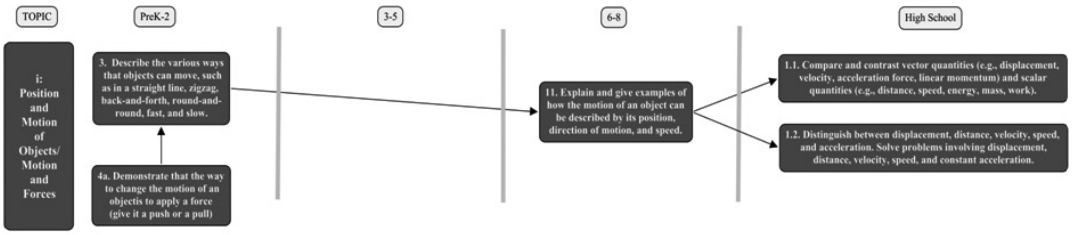


Figure 1. Portion of the Physical Science strand map showing several force and motion standards (From Strand Maps of the 2001/2006 Science and Technology/Engineering Standards http://www.doe.mass.edu/omste/maps/)

As we discuss the strand maps, we will use terminology that is specific to Massachusetts. It is worth taking a moment to define strand, topic, standard, and link. A strand is a science subject or discipline in the state Framework; each strand is represented on its own strand map and assigned a color scheme (Earth and Space Science—blue; Life Science—green; Chemistry—blue-green; Introductory Physics—purple; Technology/ Engineering—yellow-brown). A topic is a major subcategory within a strand and is assigned its own color from within the strand color scheme. For example, there are six topics within the Life Science strand: anatomy and physiology; cells and biochemistry; heredity and genetics; characteristics of living things; evolution and biodiversity; and ecology. A standard is a particular learning expectation. A standard specifies what students should know and be able to do and explicates the knowledge or skills to be assessed.

A link is an arrow that connects standards and represents the conceptual relationship between the two standards. These links are meant to make explicit the concepts that are considered necessary in order to learn later concepts, not any possible connection between concepts. Links within strands are solid; links across or between strands are dashed. An arrow leaving a standard implies that the concept contributes to learning the concept of the next, connected standard. These links are primarily based upon available cognitive research (often limited) specific to a particular idea, general principles of cognitive development (for example, concrete before abstract), logic of the subject matter, and wisdom of practice/ professional judgment.

The development of these strand maps were held to one additional principle: simpler is better. The maps aim for as few arrows and crossings as possible. Placement of topics and concepts on the maps is first by "affiliation to a topic" but when needed standards are moved to place them in closer proximity to conceptually connected standards. Figure 2 presents an excerpt highlighting two topics from the Life Science strand map that illustrate each element discussed here. Topics are listed on the left: characteristics of living things and evolution and biodiversity. Each cell encloses one standard; each arrow represents a conceptual relationship between standards.

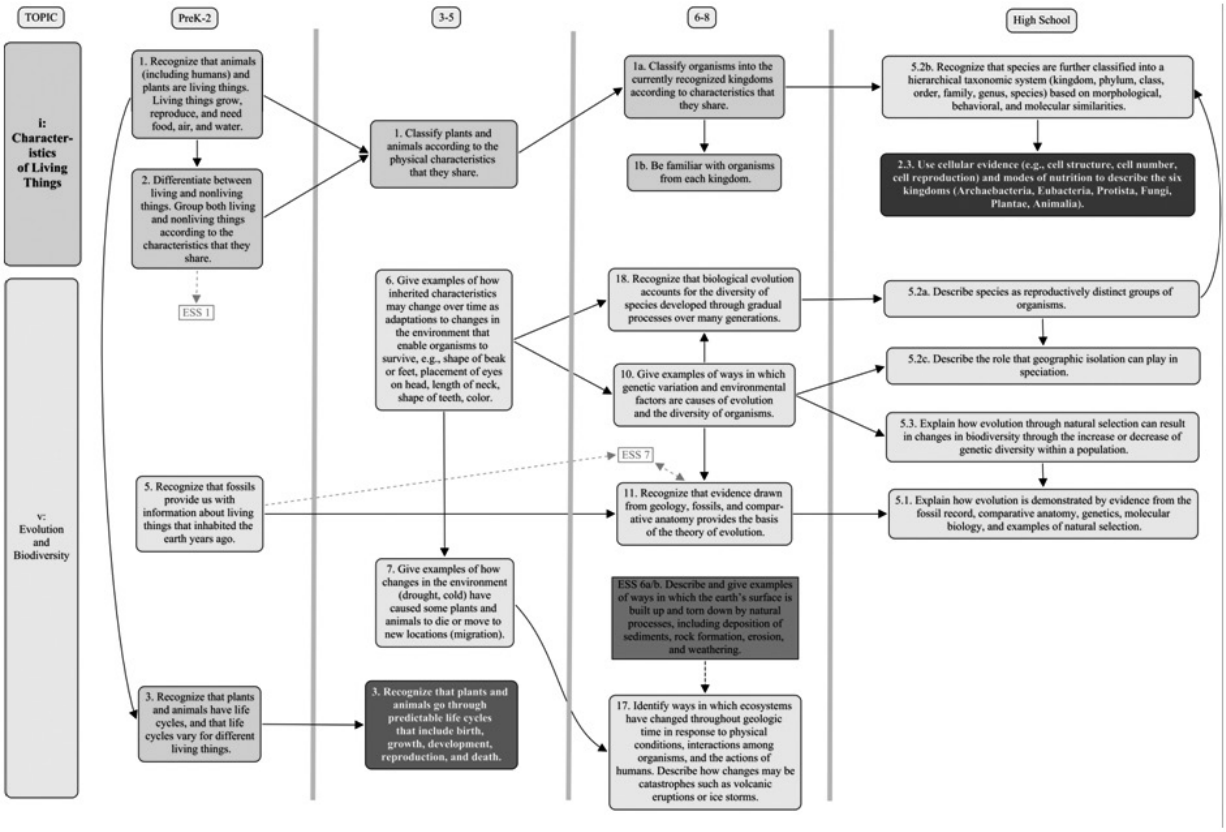


Figure 2. Excerpt from the Life Science strand map showing standards from multiple topics and crosslinking with Earth & Space Science (From Strand Maps of the 2001/2006 Science and Technology/Engineering Standards http://www.doe.mass.edu/omste/maps/).

It is worth taking a moment to distinguish strand maps and concept maps. The structure of a topic can be viewed holistically through both concept maps and strand maps. Content presented in either form provides an opportunity to more easily spot patterns of linkages than content presented through traditional bullet points or numbering schemes. While related, however, strand maps are structurally distinct from concept maps. While strand maps do show conceptual relationships between key concepts, they do not present all possible linkages; they also do not include a variety of linking words that explicate the nature of the relationship between connected concepts; nor are they designed to clarify meaning of particular concepts. Additionally, some standards expressed in strand maps may contain more than one specific concept or skill, depending on how those are written and connected to other standards. This is one distinguis-

hing feature from concept maps, in which a single concept label is generally found within each cell.

4 Features Revealed by Strand Maps

Three general features were revealed by these strand maps: 1) standards that were not conceptually supported at earlier grades; 2) two dominant ways in which standards linked across the grade spans, including diverging and converging concepts; and 3) variations in the specificity of the standards.

4.1 Unsupported standards

Some topics revealed unsupported standards, in which some upper grade-span standards did not have related standards at early grade levels. Sometimes this is quite reasonable given the topic. For example, a number of Chemistry concepts are not reasonably considered by elementary or middle school students. Further, not all grade spans must have concepts for each topic. However, this feature is revealed a number of times in each strand. For example, in engineering design, knowledge and skills needed to successfully represent problems and solutions are missing. In particular, analysis of the AAAS Atlases revealed two concepts fundamental to the development of this topic (Figure 3). Thus, the current framework targeting the topic of Engineering Design might benefit from the addition of foundation standards that emphasize student ability to "draw pictures that portray features of a thing being described" (PreK-2) and to make "scale drawings that show shapes and compare locations of things very different in size." (Grades 3-5).

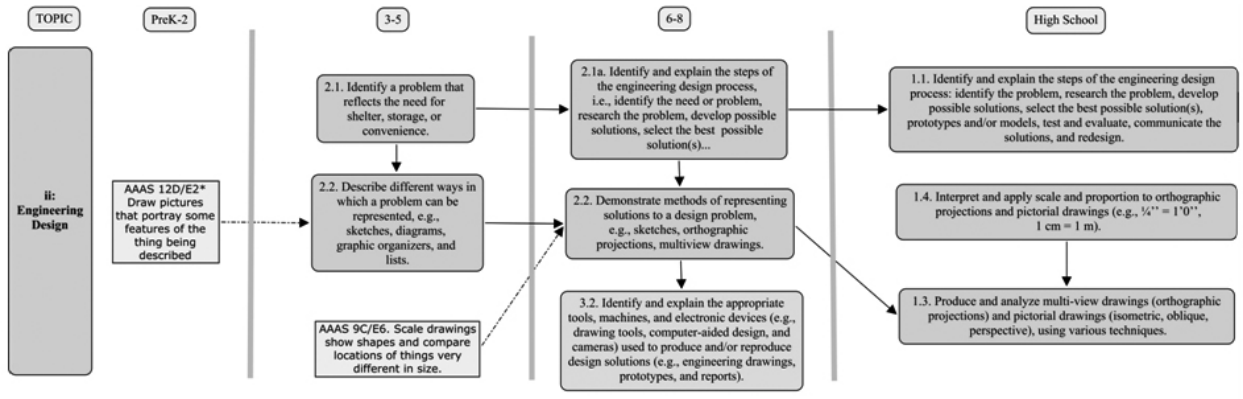


Figure 3. Portion of the Technology/Engineering strand map showing weakly supported standards for representing problems and solutions. Standards from the Atlases of Science Literacy that would better support those begin with "AAAS"(From Strand Maps of the 2001/2006 Science and Technology/Engineering Standards http://www.doe.mass.edu/omste/maps/)

A second type of unsupported standards is represented is an "opportunity-to-learn gap," a break in learning of a topic for a full grade span or more. An example of this is depicted in an excerpt from the Physical Science strand map in Figure 4. The framework stipulates that students begin learning about motion in PreK-2 but then not again until grades 6-8. This presents a large conceptual challenge, as it may be between 4 and 6 years without learning about force and motion. How to address this gap, and others like it, is a key issue in the review process. Likely the reviewers will need to reference national documents such as the AAAS Benchmarks to identify appropriate concepts for grades 3-5.

Figure 4 also illustrates a third type of unsupported standard: isolated concepts. At the PreK-2 level, a standard suggesting that students be able to "recognize that under some conditions, objects can be balanced" is not developed further at any grade level; nor is it conceptually related to any other standard. This is also the case for the high school standard suggesting that students "describe conceptually the forces involved in circular motion." Isolated content sends up a "red flag." Research indicates that arbitrary content is learned in a rote manner; i.e. not learned meaningfu-

lly, and is, therefore, less likely to be retained and applied in the future (Ausubel, 1978; Novak, 2009.)

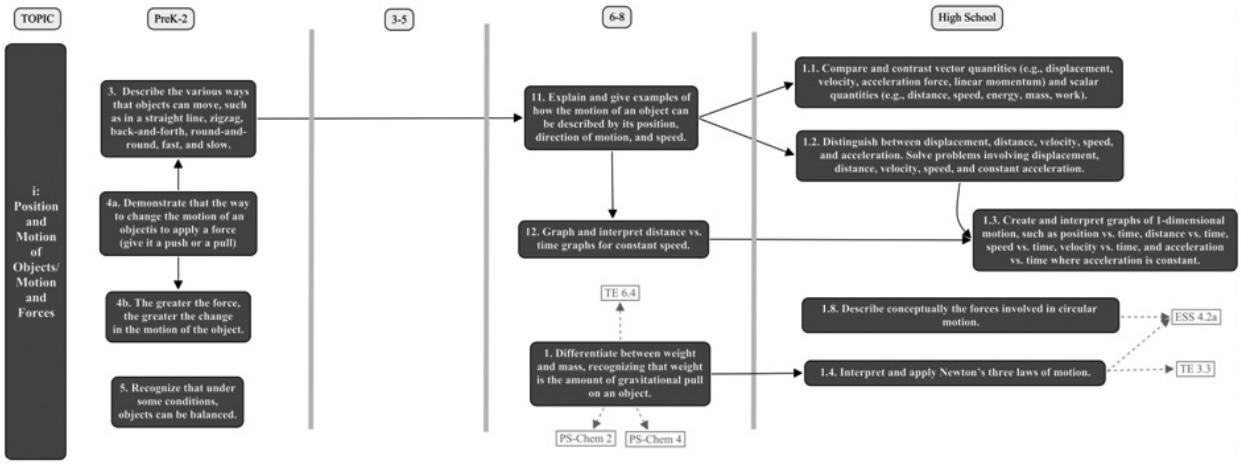


Figure 4. The force and motion topic of the Physical Science strand map showing an opportunity-to-learn gap (grades 3-5) and two isolated concepts (grades PreK-2 and HS). (From Strand Maps of the 2001/2006 Science and Technology/Engineering Standards http://www.doe.mass.edu/omste/maps/)

4.2 Patterns of divergence, convergence, and crosslinking

Three patterns of linkages among standards resonate with Ausubelian Learning Theory: diverging, converging, and crosslinking standards. Awareness of and emphasis on these linkages increase the opportunities for educators to facilitate meaningful learning by PreK-12 students in the classroom.

Diverging standards reflect what Ausubel would have called "progressive differentiation." Subordinate concepts are linked to or 'subsumed' under superordinate concepts. Learners add details to their general understandings, deepening conceptual structure. In Figure 5 below, learning about the general functions of the human body in Grades 6-8 differentiates into six standards at the high school level, each standard targeting a different system and its function.

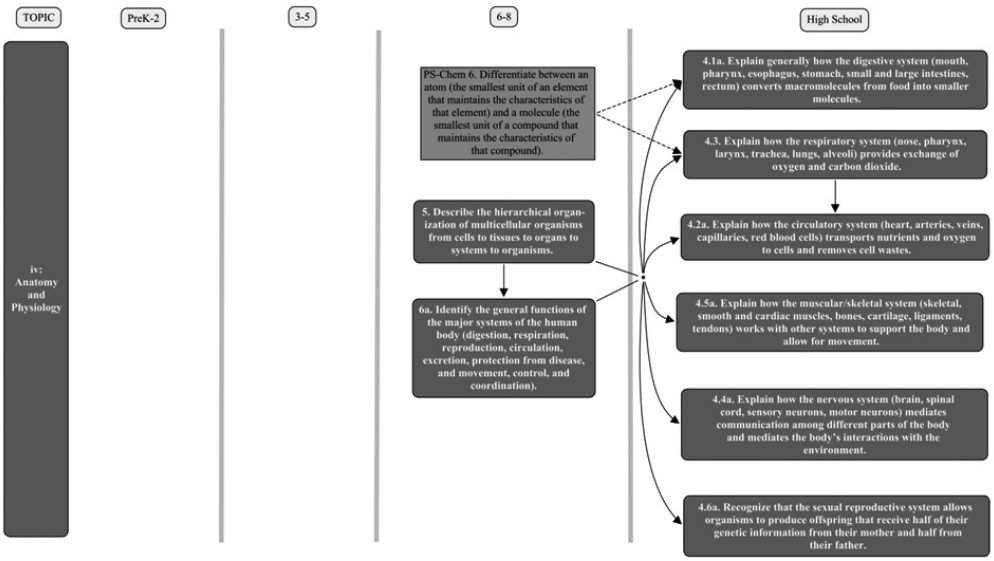


Figure 5. The anatomy and physiology topic of the Life Science strand map showing diverging concepts. This example also shows upper level standards that are unsupported in the PreK-5 grades. (From Strand Maps of the 2001/2006 Science and Technology/Engineering Standards http://www.doe.mass.edu/omste/maps/)

In a second pattern, simple ideas introduced in early years are synthesized into more complex understandings in later years. None of the relevant concepts are more general than the others. The standards represent the learning of many new linkages among concepts that are non-arbitrary and relate to a broad background of generally relevant content in cognitive structure. Ausubel might have labeled the example in Figure 6 as a "combinatorial relationship." Much construction of knowledge must be carried out in early grades in order for high school students to be able to "provide examples of how the unequal heating of Earth and the Coriolis effect influence global circulation patterns, and show how they impact Massachusetts weather and climate."

A third pattern, crosslinking between topics within a strand and between strands themselves, is also commonly found throughout the standards. For instance, in Figure 6, the PreK-2 standard "understand that air is a mixture of gases that is all around us and that wind is moving air" is an earth processes and cycles topic standard that lays a foundation for higher-level energy in the earth system topic standards. Additionally, in Figure 6, there are two standards from the Physical Science strand (found in sharp-cornered boxes with dashed arrows) that are crucial to the understanding of a Grade 6-8 standard in this excerpt from the Earth and Space Science strand.

4.3 Inconsistent specificity

Close reading of the standards reveals that some are at considerably different levels of generality. For instance, a relatively large difference in level of specificity is found between two grade 6-8 standards of the "Heredity and Genetics" topic in the Life Science strand. Standard 8 calls for very specific knowledge asking students to "recognize that hereditary information is contained in genes located in the chromosomes of each cell. A human cell contains about 30,000 different genes on 23 different chromosomes." Standard 9, on the other hand, calls for a more general level of knowledge asking students to "compare sexual reproduction (offspring inherit half of their genes from each parent) with asexual reproduction (offspring is an identical copy of the parent's cell.)".

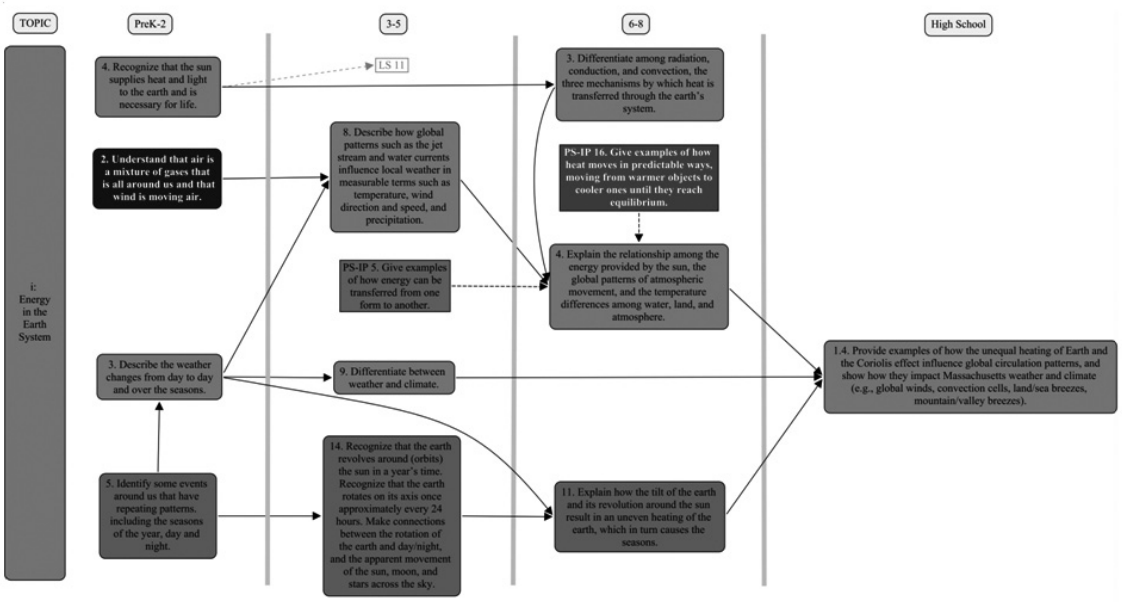


Figure 6. Portion of the Earth and Space Science strand map showing converging concepts leading to the high school standard #1.4. Crosslinking between topics and between standards is demonstrated. (From Strand Maps of the 2001/2006 Science and Technology/Engineering Standards http://www.doe.mass.edu/omste/maps/)

5 Using Strand Maps and Learning Progression Research to Revise State Standards

Learning progressions can account for how students think and learn about science from a cognitive perspective. A learning progression, by definition, bridges the scientific version of a big idea to the intuitive ideas children develop about it before formal instruction (Corcorcan et al, 2009; Wiser & Smith, 2009). While learning progressions are research-based, they are hypothetical; they are ideal paths for successful conceptual development about a big idea; they propose how a network of knowledge about a big idea could coherently evolve over long period of time from young children's ideas if students are exposed to curricula with appropriate consideration given to "concepts, stepping stones, levers, and linchpins." (Wiser & Smith, 2009; Wiser et al, 2009). That is why a learning progression can be so useful; it invites standards developers to design standards that will bring the learning progression about according to cognitively appropriate core ideas.

Considering student cognition from a learning progression basis allows standards and curriculum developers to account for prior beliefs and transitional ideas, even if those ideas are not scientifically accurate. "How students get there" is about their cognitive reconceptualization which can be seen in learning progressions that promote more of a holistic view of student thinking about scientific ideas. Finally, a learning progression approach requires careful consideration of how science content knowledge and inquiry skills relate, because how students cognitively engage with science content is key to their learning.

While we see the great value and potential of learning progressions on standards development, it is important to note that a full standards development process based on learning progressions is not possible at this time due to the early state of learning progression research. As such, the best we can do at this time is to revise our current standards to include what cognitive insights are now available. Using strand maps to visualize the progressions of standards is key to this process. For the present, our revision process will use what research is available, as well as collective wisdom of those teaching students, to appropriately address the features or patterns identified in the strand maps that may hinder student learning of science. Strand maps will help us enhance the relationships and progressions of standards to better support student learning of science.

6 Possible Extensions and Next Steps

Strand maps take a big step toward showing the Pre-K-12 grades connectivity among the Massachusetts standards. Standards connected to prior standards imply that curriculum, teacher's instruction, and student's learning will be targeted toward connectivity. Such an approach foregrounds meaningful learning over rote learning.

Strand maps offer an opportunity for an educational learning community to engage in ways that promote meaningful learning in students. By using CmapTools to visualize and manipulate the strand maps, curriculum coordinators and teachers can easily link their work to the standards, thus allowing them to visually demonstrate how their curriculum aligns with the commonwealth's curriculum frameworks. This process is considerably easier than past efforts to visualize such alignment (Heinze-Fry, 2006).

Both strand mapping and concept mapping are tools that facilitate meaningful learning within the educational community. Both target connected knowing of concepts rather than arbitrary rote learning and isolated content. They differ, however, somewhat in target audience and scale. Strand maps, such as those demonstrated by the National Science Digital Library AAAS maps, are hypothetical conceptual superhighways linking the big ideas of science and demonstrating possible linkages among them. Such maps are especially useful to standards-setting State Departments of Education and Curriculum Coordinators for individual school systems. Concept maps, on the other hand, are more often created by teachers to demonstrate how they are connecting concepts within their discipline. Students create concept maps to demonstrate how they are connecting new concepts to their prior knowledge and particular exemplars that clarify the meaning of that concept for them. Novak describes how students, using skeletal expert concept maps, can create their own differentiated learning using Internet resources, experiments and field experiences, and other learning experiences (Novak, 2009). Over time, these maps can demonstrate lifelong learning over the preK-adult span. Portfolios demonstrate such an approach.
CmapTools is software which can be used to link all of these efforts together. Curriculum coordinators can parse the

requisite knowledge into expert concept maps that clearly label the relationship between concepts. The advantage here is that the curriculum coordinator can directly link their school or school system's goals to the standards while fleshing their meaning out for educators. Teachers can also link their instructional efforts to the curriculum coordinators work. Students, in turn, can demonstrate mastery of subject matter by linking their learning efforts to the teachers' instruction. A demonstration of this vision can be found at http://cmapspublic3.ihmc.us/rid=1HL3HCVNB-8H9KH3-J6J/Vision.cmap. The vision demonstrates that the educational professional and governing institutions can articulate the standards of scientifically literate citizens, and school systems, individual teachers, and students can demonstrate their unique pathways to addressing those standards.

7 Summary

Using the Atlases of Science Literacy as a model, strand maps of the Massachusetts Science and Technology/Engineering Framework were created to facilitate the curriculum review process. Through visual representation, these maps demonstrate unsupported standards, patterns of divergence, convergence, and crosslinking, and standards of inconsistent specificity. Using these strand maps and research in cognitive science and learning theory, revised maps are likely to show more complete learning progressions in the preK-12 grade spans. Highlighting the converging, diverging, and crosslinking standards as well as the use of CmapTools in creating the standards opens opportunities for further integration of all members of the educational community.

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Viña del Mar, Chile, 2010

CONCEPT MAPS CORE ELEMENTS CANDIDATES RECOGNITION FROM TEXT

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Abstract. A concept map is a schematic resource to represent and organize a set of meanings in a propositional structure. In a learning process, the practice of making and remaking concept maps might be considered as an effort to find out concepts and their meanings, giving rise to the knowledge in an explicit way (Novak & Gowin, 1984). Computer aided programs can make the choice to use concept maps easier than before. Over the last few years, many basic functions in concept maps building, such as publishing and sharing, were facilitated by computer aided programs. An increasing interest in applying computational resources to automatically build concept maps from data sources by extracting concepts and linking words has emerged recently. In this paper, we propose an approach focused on the recognition of concept maps' core elements in texts and, in addition, we expose the initial results of the experiment conducted in the Brazilian Portuguese Language.

1 Introduction

A concept map is a schematic resource to represent and organize a set of meanings in a propositional structure. In a learning process, the practice of making and remaking concept maps might be considered as an effort to find out concepts and their meanings, giving rise to the knowledge in an explicitly way (Novak & Gowin, 1984).

In general, a concept map springs up from early scratches and much iteration is required to improve it. Hence, it is worth noting that, in some research fields, the process of concept maps building needs to overcome costs and reducing of the time and the efforts in knowledge acquisition activities (Chang et al., 2008; Lee et al., 2009; Tseng et al., 2007), especially, in large knowledge domains highly dependent on experts (Valerio & Leake, 2006). Considering this issues, it is undeniable that computer aided programs work in favor of the practice of thinking using concept maps.

Over the last few years, many basic functions in concept maps building, such as publishing and sharing, were facilitated by computer aided programs. Recently, an increasing concern in applying computational resources to build concept maps automatically from data sources by extracting concepts and linking words have came out. In fact, according to Kowata, Cury & Boeres (2009), 10 of 15 approaches to build concept maps automatically were published in the last three years, most of them (93.34%) concerned with educational (46.67%) and analytical purposes (46.67%). They noticed that 66.67% of the whole approaches used unstructured sources, i.e., natural language texts. With regard to the most applied manipulation methods for unstructured sources, it was observed that only hybrid and linguistic methods produced complete concept maps, representing 33.33%, in counterpart to incomplete maps produced by pure statistical methods.

All exposed information in Kowata, Cury & Boeres (2009) cannot drive us to final conclusions. However, that research outlines a trend, also a challenge, in concept maps building: the growing use of unstructured data sources as primary resource to derive human-understandable concept maps.

With this challenge in mind, we have started a project which aims to define a hybrid approach to handle unstructured data sources in Brazilian Portuguese Language to produce complete concept maps for support learning objects on e-learning environments. In this paper, we propose an approach focused on concept maps core elements recognition in texts. In addition, we expose the initial results of the experiment conducted with a Brazilian Portuguese Language corpus.

The present paper is organized as follows: in Section 2 we go into concept map as a knowledge representation

language, highlighting their core elements; in Section 3 we put forward our approach to handle unstructured data source to recognize concept maps core elements candidates; in Section 4 we present an overview of similar approaches; at last, in Section 5 we carry out for pointing up our preliminary findings and our future works.

2 Concept Map as Knowledge Representation Language

The concept map language was inspired by Ausubel's Assimilation Learning Theory and Constructivist Epistemology, known as Meaningful Learning Theory. Ausubel stated that the human cognitive structure is an organized and hierarchical space in which the learning process takes place (Novak & Gowin, 1984). During the learning process, new concepts are linked to existent ones by means of propositional statements in a movement called "subsumption" (Cañas et al., 2003). Concept map language exhibits these theoretical assumptions in three major features: a) concepts are organized in a semi-hierarchical way where the more general ones subsume the more specific ones; b) concepts are labeled by a couple of words that defines "a perceived regularity in events or objects, or records of events or objects" (Novak & Gowin, 1984); c) the relationship between two concepts must be labeled in a form so that propositions may be identified.

The two necessary elements of any concept maps are "Concept" and "Relationship". We referrer them as "core elements" to make distinction with resources that was introduced later by some of computer aided tools. Not all concept maps contain additional resources. They act as complimentary resources and comprise format as images, video, web pages, comments or embedded concept maps.

We depict in Figure 1 the concept map language meta-model [1], i.e., it shows the constructs that we can use to build a concept map. We defined that all core elements derive from the same ancestral called "Element". "Element" is a set complete and disjoint, and one instance of element should be or a "Concept" or a "Relationship".

Elements can be enriched by resources and also can be annotated by author's comments. The ontological difference between relationships and concepts are related with their meanings in the real world. While concepts represents "things and events", relationships represents "acts and process". Furthermore, relationships are completely dependents on concepts: in a concept map, the existence of relationships doesn't make sense without "target" and "source" concepts.

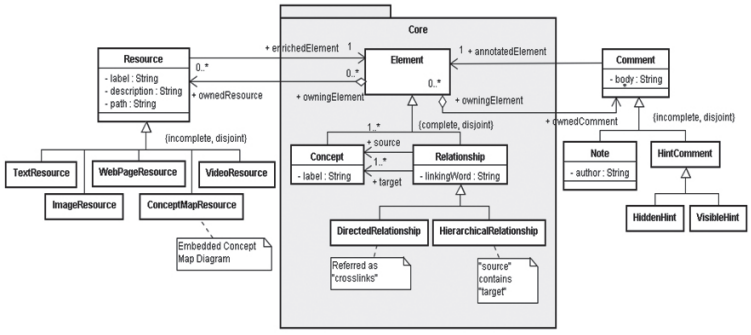


Figure 1. Concept Map Language Meta-model

3 Concept Maps Core Elements Candidates Recognition

This research was conceived with two fundamental assumptions: (i) try to put forward an approach that could work with unstructured data source and (ii) the resulted concept maps should be understandable to humans. The first assumption related to "work with unstructured data source" assumes that the proposed approach have to face the complexity of the natural language, while the second one, about "produce understandable output to humans", means that

[1] A meta-model is composed by language and rules that define the process and elements of the model.

the process of building concept map from a text should offer minimum semantic losses and preserve the main idea of the source.

For achieving results that could be adherent to the defined assumptions, we try to propose a whole approach with several minor solutions, each one concerned with a single problem. Actually, we design a pipeline with a set of coordinated tasks in which each task depends on the output of a previous task and produce an output used in the next task, as depicted in Figure 2.
related to "work with unstructured data source" assumes that the proposed approach have to face the complexity of the natural language, while the second one, being comprehensible, means that the process of building concept map from a text should offer minimum semantic losses and preserve the main idea of the source.

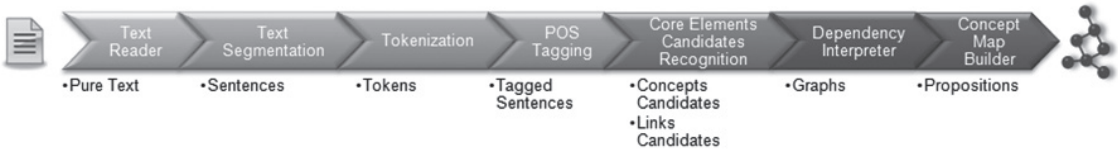


Figure 2. Pipeline to build Concept Map from text

In "Learning How to Learn", Novak & Gowin (1984) stated that the choice of words is very important to label concepts and relationships. Keeping in mind that sentences are a list of words arranged under syntactical rules, we focused on finding out the more suitable subset of these words to name the core elements of concept maps.

We defined a metaphor "disassemble to reassemble" to guide the search for concept and relationships from sentences in natural language. Step by step, we gradually broke up a text until its structure became visible, emphasizing the "disassembling" stage: at first by removing format tags in order to find out a pure text, then by splitting the text in sentences, and at last, by identifying independent tokens. In turn, each token was identified with its Part-of-Speech tag[2] (POS tag). From this point on, another bias would take place, highlighting the "reassembling" stage. Using a set of linguistic patterns based on POS tag, specific linguist chunks[3] were recognized in an activity called "Core Elements Candidate Recognition". In next stages, candidates were mapped into graph[4] nodes. Just over another transformation from graph to concept map, we can find out "concepts" and "relationships", as depicted in Figure 3.

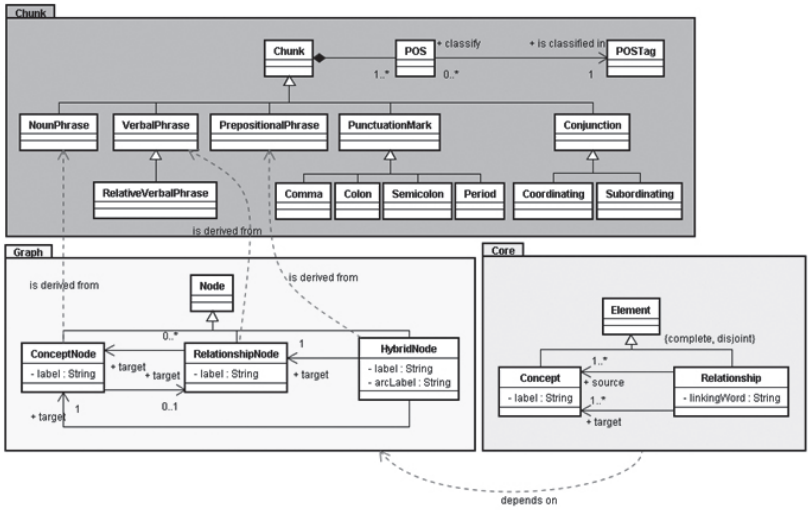


Figure 3. Mapping Chunks, Graphs and Core Elements

[2]Part-of-Speech tag (POS tag) is a label that identifies a "word class", for instance, nouns, verbs, adjectives, adverbs, prepositions, etc.
[3]Linguistic chunk is a sequence of words that make sense when disposed together. Among these words there is only one that is indispensable, often, a noun or verb.
[4]Graph is a mathematical structure composed by nodes and arcs

3.1 Core Elements Candidates

As in English Language, in Brazilian Portuguese it is also possible to identify sequences of words surrounding at least one noun (Noun Phrase), verb (Verbal Phrase), or preceded by a preposition (Prepositional Phrase). These sequences compound what we call "linguistic chunks".

According to Novak & Gowin (1984) it is essential to isolate concept from linking words (relationships). Both of them are important as language units, but they play different roles in the transmission of meaning. While concept is labeled by words that represent things and events, relationships are a way to link two concepts in a propositional form. Novak & Gowin (1984) did not define any correlation between concept maps elements and linguistic chunks. However, according to their directions to build a concept map, we could consider Noun Phrase (NP), Verbal Phrase (VP) and Prepositional Phrase (PP) as primary candidates to be mapped as Concept Maps Core Elements. Noun Phrase (NP) is the most important candidate to be a concept; Verbal Phrase (VP) is aspirant to be a relationship, and Prepositional Phrase (PP) could be both a concept, taking the essence of the Noun Phrase, and a relationship, if we consider the preposition that appears before the Noun Phrase.

As a general rule, sentence chunking is an important task for recognizing the core elements candidates. Chunks are created by a set of linguistic patterns, each of them described by regular expressions, in Brazilian Portuguese language. An example of linguistic patterns for NP recognition in Portuguese Language can be seen in Table 1.

#	LINGUISTIC PATTERNS	EXAMPLE
1.	NP: {<N.*|NPROP.*|ADJ|AP>+}	**"PAZ"** (as in English: "PEACE")
2.	NP: {<ART>?<NP>}	**"A PAZ"** (as in English: "THE PEACE")
3.	NP: {<NP>+{<KC>?<QUAL.*><NP>}+}	**"SEMANA DA PAZ"** (as in English: "WEEK OF PEACE")
4.	NP: {<NP><PCP>}	**"SEMANA PASSADA"** (as in English: "LAST WEEK")
5.	NP: {<\(><NP><\)>}	**"(PAZ)"** (as in English: "(PAZ)")
6.	NP: {<NP><,|-><NP><,|-|\.>}	**"SEMANA PASSADA, SEMANA DA PAZ,"** (as in English: "LAST WEEK, WEEK OF THE PEACE,")
7.	NP: {<NP>+<QUAL.*|PREP.*>+<V>+<NP>}	"**CAPAZ DE ALCANÇAR A PAZ**" (as in English: "CAPABLE OF REACHING PEACE")
8.	NP: {<NP><KC|,><NP>}	"**AMOR E PAZ**" (as in English: "LOVE AND PEACE")
9.	NP: {<NP>+}	"**PESSOA CAPAZ DE ALCANÇAR A PAZ**" (as in English: "PERSON CAPABLE OF REACHING PEACE")

TAG LEGEND:

NP - Noun Phrase	ADJ - Adjective	PCP - Past Participle	? - Optional
N - Noun	AP - Apposition	V - Verb	| - Or
NPROP - Proper Name	KC - Conjunction	* - Zero or more	<> - Set
ART - Determiner	QUAL - Qualifier	+ - One or more	, - Comma

Table 1. Linguist Patterns for NP Recognition in Brazilian Portuguese Language

In the Core Elements Candidates Recognition task, a program takes a tagged sentence (Figure 4a) and searches for all structures that match with the defined patterns. This is performed recursively until each production rule has been processed. At the end, specific chunks are identified (Figure 4b), such as: Noun Phrases, Verbal Phrases, Prepositional Phrases, Punctuation Marks, and Conjunctions etc.

Each chunk has a particular behavior when it is put together with another chunk, for example: VP always wants to attach an NP above it, but, it usually ignores a PP that appears in the same condition. These behaviors were codified into a program that, with some rules, identifies dependencies between the chunks. When a binary dependency is identified, each chunk instance is mapped into a graph node instance and the relation between them is explicitly represented by a labeled arc. Each NP is mapped into an instance of ConceptNode, VP into RelationshipNode, and PP into HybridNode, as depicted by Graph Package in Figure 3. This way, a graph is built to be an intermediate structure between a text and a concept map.

Graphs were chosen as an intermediate structure, because their form with nodes and arcs is very similar to a con-

cept map. Besides that, they don't have constraints to deal with binary relations. From this point of view, graphs are more flexible than concept maps, considering that in the latter there is the requirement to produce propositions. As we can observe, in graphs, a relationship could also be represented as a node in the same way as a concept. Therefore, to transform the graph nodes into concept maps elements is an indispensable stage to build a concept map.

```
As/ART doenças/N que/PRO-KS-REL estão/VAUX
atacando/V as/ART lavouras/N gaúchas/ADJ de/PREP
soja/N podem/VAUX ocasionar/V a/ART extinção/N
de/PREP|+ a/ART cultura/N em/PREP|+ o/ART Estado/N
./.
```

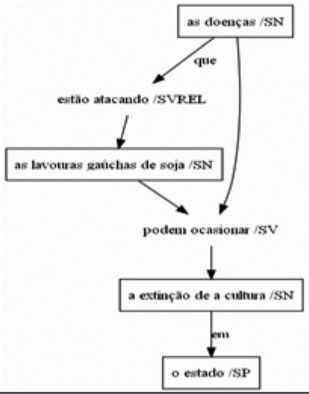
(a) Tagged Sentence

```
(S
  (NP (NP As/ART (NOME doenças/N)))
  (VPREL que/PRO-KS-REL (VP (VP estão/VAUX (VP
(VERBO atacando/V)))))
  (NP
    (NP
      (NP as/ART (NOME lavouras/N gaúchas/ADJ))
      de/QUAL
      (NP (NOME soja/N))))
  (VP (VP podem/VAUX (VP (VERBO ocasionar/V))))
  (NP
    (NP
      (NP a/ART (NOME extinção/N))
      de/QUAL|+
      (NP a/ART (NOME cultura/N))))
  (PP em/PREP|+ (NP (NP o/ART (NOME Estado/N))))
  (PONT ./.))
```

(b) Chunks Recognized

```
digraph G {
compound=true;
node1 [shape="rectangle",label="as doenças /SN"];
node2 [shape="none",label="estão atacando /SVREL"];
node3 [shape="rectangle",label="as lavouras gaúchas
de soja /SN"];
node4 [shape="none",label="podem ocasionar /SV"];
node5 [shape="rectangle",label="a extinção de a
cultura /SN"];
node6 [shape="rectangle",label="o estado /SP"];
node1->node2 [label="que"];
node1->node4;
node2->node3;
node3->node4;
node4->node5;
node5->node6 [label="em"];
}
```

(c) Graph in dot Format



(d) Graph

Figure 4. Pipeline's outputs

4 Case study

We selected MAC-MORPHO, which uses Brazilian Portuguese Language, from the Lácio-Web Project (Aluisio et al, 2004), to test the approach. This linguistic resource comprises approximately 1.2 million words, which was manually-validated for morpho-syntactical tags, distributed in 51,397 annotated sentences.

From the body of MAC-MORPHO, we selected 2% of texts, splitting each of them in sentences. As a result, we had 927 sentences processed, 927 graphs produced, 1710 VP, 2059 NP, and 1505 PP identified. These numbers correspond to an approximately 1.84 VP, 2.22 NP, 1.62 PP, and an average of 21.54 tokens per sentence. In general, each sentence, in average, was reduced to 4 main chunks (NP and VP) and 1 complement (PP).

The graph building program was codified and compiled using Python 2.6.5 (Python, 2010), using Natural Language Processing Toolkit (Bird, Klein & Loper, 2009) and GvGen (GvGen, 2007) – a Python module used to generate Graphviz-compatible dot files. To visualize the graphs, we used Graphviz (Graphviz, 2010).

4.1 Preliminary Analysis

The 927 results were classified in three major clusters, according to the graph comprehensibility. The clusters are: C1 – Not Understandable, C2 – None, C3 – Understandable.

The clustering was conducted by human experts that have compared the original source with the graph result. Using a simple checklist, they classified each of the 927 cases in only one cluster. In addition, it was demanded that notes were gathered, such as the number of improper chunks, of ignored chunks, of additional links, and ignored links.

A summary of the work can be seen in Table 2 where we can observe that 3.67% of the cases were classified as not readable while 94.17% were considered readable. In 2.16% the program could not produce a graph output.

Cluster	Corpus		Corpus Structure										Result Notes			
Understandability	Quantity	Percentage	Tokens	Verbal Phrase	Noun Phrase	Prepositional Phrase	Relative Pronoun	Apposition	Comma	Coordinating Conjunction	Subordinating Conjunction	Apposition with Preposition	Improper Chunks	Ignored Chunks	Additional Links	Ignored Links
Not understandable (C1)	34	3.67%	**28.79**	**2.62**	**3.50**	**2.03**	0.00	**0.12**	0.18	**1.44**	**0.44**	**0.74**	**0.23**	**0.18**	**0.91**	**1.18**
None (C2)	20	2.16%	5.65	0.40	0.65	0.20	0.00	0.00	0.05	0.20	0.00	0.00	0.00	0.00	0.00	0.00
Understandable (C3)	**873**	**94.17%**	21.63	1.85	2.21	1.64	0.00	0.03	**0.24**	0.76	0.29	0.24	0.07	0.05	0.41	0.14
Summary	**927**	**100.00%**	**21.54**	**1.84**	**2.22**	**1.62**	**0.00**	**0.03**	**0.24**	**0.77**	**0.29**	**0.26**	**0.08**	**0.05**	**0.44**	**0.20**

Table 2. Summary of Preliminary Analysis

In the C1 cluster, we found out that the body of the input has high occurrences of tokens, chunks and misunderstood chunks in comparison to C2 and C3 cluster. We could infer that this, in some way, influenced the semantic quality of the results.

The C2 cluster represents cases where it was not possible to recognize links between elements of chunks. In fact, the links depend on the existence of verbal phrases. This cluster has low average of tokens, especially of verbal phrases.

The C3 cluster contains understandable structures in comparison with the source sentences, representing 94.17% of the whole sample.

The preliminary results show that the approach was successful to handle the major part of the body [of language] in a satisfactory way. Considering the results, we could observe that the approach worked successfully with incomplete sentences, subordinated and coordinated forms, as well with topicalized forms. However, lots of work remains to be done to improve the program performance. It still needs to evolve and to be more robust in dealing with the anaphora phenomena, apposition and interrogative as well as imperative sentences.

5 Similar Approaches

The use of linguistic methods to build a concept map from text is not a new approach (Kowata, Cury & Boeres, 2009). In fact, Valerio & Leake (2006) also used Noun Phrases and Verbal Phrases to extract concepts and relationships. In another way, Pérez & Vieira (2004; 2005) proposed to handle syntactic chunks as subject, predicate and objects and mapped them to core elements by using a set of rules. Alves, Pereira & Cardoso (2001) used linguistic methods associated to machine learning methods to create binary predicates based on external lexical resource. Lau et al. (2008) used forum and chat texts and extracted concept maps from them by applying linguistic patterns and statistical methods to compute the relevance of each concept. Richardson & Fox (2007) and Richardson, Srinivasan & Fox (2008) extracted propositions from theses and dissertations by using a tool to handle texts and extract information of

them. Zouaq & Nkambou (2008, 2009) extracted key concepts from natural language text using machine learning and linguistic methods.

The most relevant difference between the mentioned approaches and the approach presented in this paper are:

a) we aim to produce one concept map from one text, in counterpart of Valerio & Leake (2006) and Zouaq & Nkambou (2008, 2009) that retrieves information of more than only one text;

b) we propose the use of raw text as input of concept maps building approach, differently from Pérez & Vieira (2004, 2005) that require pre-tagged texts;

c) we don't ignore stop words – actually we consider that it is very important to define the dependency between concepts and relationships –, such as prepositions and punctuations, as we can verify in Lau et al. (2008);

d) we aim to produce comprehensible concept maps and a concept map is our primary goal, differently from Zouaq & Nkambou (2008, 2009) that uses concept maps as intermediate language to build ontologies;

e) we do not restrict the set of linking words, which is in opposition to Alves, Pereira & Cardoso (2001).

To sum up, it is important to highlight that we propose an approach to build concept maps from text, describing each task in detail and offering a single tool that supports all the tasks, in a clear way to the end user.

6 Future Works

We have noticed that the heuristic used to build dependencies between graphs nodes could present better performance. Thus, it is necessary to improve it or define others that could deal better with ambiguity of prepositional phrases, anaphora phenomena, apposition and interrogative and imperative sentences.

Future works also include the evaluation of taggers for Brazilian Portuguese Language in order to select one more suitable to the research needs and the development of a prototypical tool to build concept maps automatically from the inputted text.

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CONCEPT MAP-BASED ASSESSMENT FOR ADULT LEARNERS

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Abstract. Abstract. The use of Concept Maps for assessment of learning in children has been studied extensively. Likewise, though to a much lesser extent, Concept Map-based assessment for adult learners in a training context has also been investigated. The research base suggests that Concept Map-based assessment is a valid and reliable approach for assessing learning. This study builds on previous research by using Concept Maps to assess the learning of adult military service members in the context of training for deployment into hostile regions. Specifically, the training intervention concerned the topic of Improvised Explosive Devices. Concept Mapping was employed to identify knowledge differences between service members who had extensive experience with IEDs, and those who had little or none. Areas of assessment were developed from these knowledge differences. Concept Map-based assessment items—Multiple Choice Concept Maps—focused on the areas of assessment were developed and used to test for the training impact of a learning experience. The items were suggested to be sensitive to changes in knowledge.

1 Introduction

The use of Concept Maps for assessment of learning in children has been studied extensively (Mintzes et al., 2000; Novak & Gowin, 1984). Borrowing from Schaal's account (2008), we can reasonably state that the "validity and reliability of concept mapping assessment has been properly explored."

To a lesser extent, the use of Concept Maps for assessment of adult learners in a training context has also been studied. Stevens' dissertation work is, to our knowledge, the only empirical study examining this issue. In the context of evaluating the learning impacts of a 40-hour training course for personnel working with hazardous waste, she found that "predrawn fill-in concept maps can be used as an alternative method for quantitatively assessing adult learning in training situations" (Stevens, 1997, p. viii).

Similar to Stevens' approach, we have a need to understand the impact of a training intervention on adult learners. Under sponsorship from the U.S. Department of Defense, we have developed an interactive, virtual training intervention for military service personnel focused on the problem of improvised explosive devices (IEDs). Our intervention—Insurgent Mindset Training (IMT)—places service personnel in a virtual gaming environment—Virtual BattlespaceTM (VBS2) from Bohemia Interactive—and requires them to make decisions with regard to detecting and responding to IEDs. Our need is to evaluate the impact of this training intervention on adult learners. We have adopted an approach to assessing this intervention based on extensive use of Concept Mapping.

This paper reports on the use of Concept Mapping and Concept Maps for assessment of adult leaners. A four-stage approach was adopted. First, Concept Mapping-based knowledge elicitation was employed to identify knowledge differences between service members who have had extensive, real-world experience encountering IEDs, and those who have had little or none. Next, areas of assessment were identified using the Concept Maps developed during the knowledge elicitation. Next, Concept Map-based assessment items, focused on the areas of assessment, were developed. These items were examples of a novel invention—Multiple Choice Concept Map items. The items were used to test for the impact of a learning experience—i.e., training with IMT. CmapTools was used to enable several of the stages.

This paper reports on the methodology of the four-stage approach. Because of the sensitive nature of the domain, this paper does not include specific content in any Concept Maps—only structures are shown. Where appropriate, content is described.

2 Stage 1: Concept Mapping to identify knowledge differences

In June 2010, we employed Concept Mapping with 11 service members from the U.S. Army at Fort Richardson, near Anchorage, Alaska. The goal of this stage was to identify knowledge differences between the service members, using Concept Map-based knowledge elicitation techniques (Moon, Hoffman, Novak & Cañas, in press) and CmapTools.

2.1 Concept Mapping with Experienced service members

Two researchers independently co-created Concept Maps with each of the service members. The researchers conducted one-hour sessions with four highly experienced service members ("Experienced"). Specifically, this group was comprised of service members who have served in a small unit, and have several experiences conducting mounted or dismounted patrols in which insurgent activities were discovered, IEDs were found, or IEDs were detonated. Most importantly, they were identified by their peers as being proficient at countering the IED threat.

The focus question for all sessions was "What are the features of an area where you can anticipate IED threats?" This focus question was determined by our previous work in understanding the cognitive challenges inherent in IED detection and response (Phillips, Moon, Yeager and Baxter, 2009). The question was purposefully broad-based in asking about "features of an area" in order to allow the service members to report on any features, e.g., geospatial and human.

One Concept Map was created for each Experienced service member, yielding four Concept Maps and a total of 247 propositions (i.e., concept – linking phrase – concept). The largest Concept Map included 99 propositions, the smallest 45, and the average number of propositions was 61.75.

Using techniques described by Harter and Moon (2010), we merged and organized the set of Concept Maps into one large Concept Map, which provided us with a composite look at the entire dataset of propositions, organized into themes. The composite Concept Map is shown in Figure 1. It includes 251 propositions. The propositions were organized into four themes, and color-coded. In pink are propositions related to BLUFOR, or features of the area dealing with friendly forces. Orange includes propositions related to Insurgents. Yellow are propositions regarding Terrain. And green are propositions dealing with the Local Population. The content of the propositions is not shown. To provide an example of the content, one set of propositions reads: Insurgents > have > Plans, Plans > are about > Initiation (i.e., the mechanism that initiates the explosion), Initiation > includes > command wire.

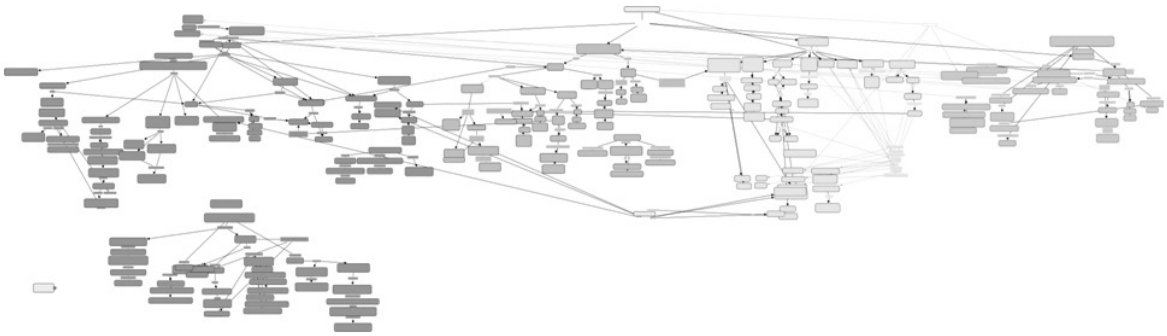


Figure 1. Composite Concept Map – Experienced Group.

2.2 Concept Mapping with lesser experienced service members

We also conducted Concept Map-based knowledge elicitation sessions with five intermediate-level experienced service members ("Intermediate"). Specifically, this group was comprised of service members who had less operational experience than the experienced performers. Finally, we conducted Concept Map-based knowledge elicitation sessions with two novice performers ("Novice")—i.e., service members with no deployment experience. The focus question for these sessions was the same as with the experienced performers.

One Concept Map was created for each Intermediate service member, yielding five Concept Maps and a total of 229 propositions (i.e., concept – linking phrase – concept). The largest Concept Map included 61 propositions, the smallest 37, and the average number of propositions was 45.8.

As with the Experienced group, we merged and organized the set of Concept Maps from the Intermediate group into one large Concept Map, which provided us with a composite look at the entire dataset. The composite Concept Map is shown in Figure 2. It includes 190 propositions. The propositions were organized into six themes, and color-coded. In pink are propositions related to BLUFOR; orange includes propositions related to Insurgents; yellow are propositions regarding Terrain; and green are propositions dealing with the Local Population. In blue are propositions about Afghani Forces, and in purple are propositions about Locations.

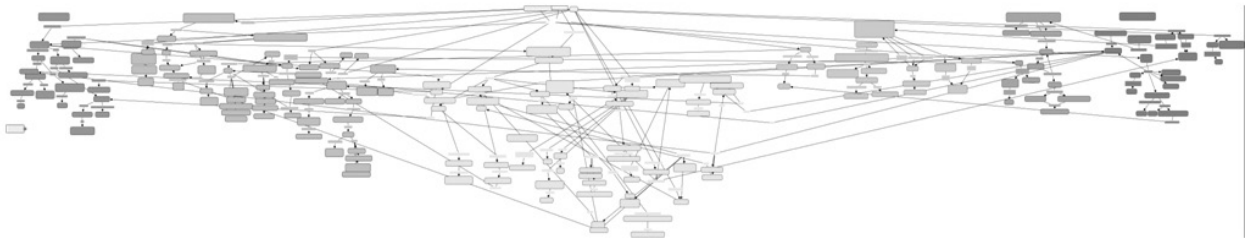


Figure 2. Composite Concept Map – Intermediate Group.

One Concept Map was created for each Novice service member, yielding two Concept Maps and a total of 62 propositions (i.e., concept – linking phrase – concept). The largest Concept Map included 40 propositions, the smallest 22, and the average number of propositions was 31.

As with the other groups, we merged and organized the set of Concept Maps from the Novice group into one large Concept Map, which provided us with a composite look at the entire dataset. The composite Concept Map is shown in Figure 3. It includes 62 propositions. The propositions were organized into five themes, and color-coded. In pink are propositions related to BLUFOR; orange includes propositions related to Insurgents; yellow are propositions regarding Terrain; in purple are propositions about Locations; and green are propositions dealing with the Local Population.

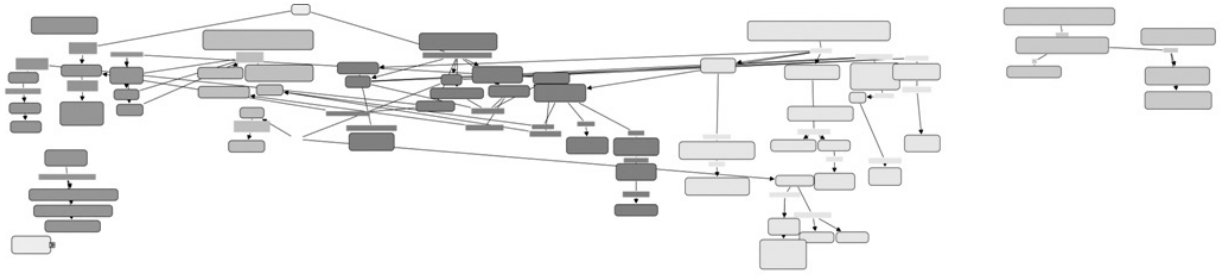


Figure 3. Composite Concept Map – Intermediate Performers.

Table 1 presents a quantitative comparison of the Concept Maps across groups. While the total N is small, differences in the volume of propositions are noticeable. These counts lent credibility to the existence of real knowledge differences between the groups.

When the Composite Maps are viewed without the benefit of the text and at large scale, it may appear that the Experienced Group and Intermediate Group demonstrate very little difference. Deeper analysis reveals the differences, however. Table 1 presents a quantitative comparison of the Concept Maps across groups. While the total N is small, differences in the volume of propositions are noticeable. These counts lent credibility to the existence of real knowledge differences between the groups.

Propositions per Concept Maps, by experience level	Experienced (N=4)	Intermediate (N=5)	Novice (N=2)
Average Propositions	61.75	45.8	31
High	99	61	40
Low	45	37	22

Table 1. Propositions per Concept Maps, by experience level

In addition to the differences in the volume of propositions, significant differences in the nature of the propositions were also identified, as we discuss in the next section.

3 Stage 2: Area of Assessment development

In our next stage we compared the three composite Concept Maps to identify areas that are ripe for assessment—i.e., areas that show stark differences in knowledge between the three groups.

We conducted a qualitative comparison of the composite Concept Maps, using CmapTools. The most salient point of comparison was the emergence of similar themes. Specifically, each Concept Map included propositions dealing with BLUFOR, Insurgents, Terrain and the Local Population. The overlap in these themes lent validity to our use of the Concept Map-based knowledge elicitation approach, and lent reliability to our use of the same focus question across groups.

The Intermediate group also included Location and Afghani Forces as themes, while the Novice group also included propositions related to Location. This suggested one area of difference. The Expert group did not seem to consider Location an important feature. We speculate that this omission was due to the operational reality that IEDs have been discovered by the Expert group in many and diverse locations.

Our comparison revealed other qualitative differences, primarily between the Expert group and the other two groups. In particular, the Expert group included more detail within each theme. While the Novice group only touched on topics within each theme, and the Intermediate group added some details, the Expert group included very specific, and in most cases more, details.

Also, the focus of the Expert group was more nuanced. With their propositions, the Expert group reflected a perspective on themselves that the other groups did not. They considered how Insurgents view them and the environment, how they should prepare for the operational environment, and how the Local Population's perspective is shaped. These nuance differences became our focus of assessment, within the thematic areas. Importantly, these were areas of assessment that coincided with the learning objectives intended to be met by IMT. Thus, the differences between the Expert and other two groups' Concept Maps provided us with content—in the form of propositions—with which to develop our assessment items.

4 Stage 3: Concept Map-based assessment items development

With the assessment areas identified, we developed Concept Map-based assessment items. Our initial items took the form of Multiple Choice Concept Maps (MCCM) items, a novel invention.

4.1 Item development process

The IMT is intended to help develop expert-level thinking with regard to IEDs. Thus, we relied on the Experienced Group's Composite Concept Map for content with which to develop the items. In particular, the concepts and propositions in the areas of BLUFOR, Terrain, and Local population included concepts and propositions that were more extensive than the other groups. Thus, these areas were brought into new Concept Maps. Again drawing on the techniques developed by Harter and Moon (2010), the concepts and propositions were arranged to represent Concept Maps that directly expressed the assessment areas—i.e., Concept Maps that clearly expressed the Experienced group composite perspective. Extraneous concepts and propositions were eliminated, and some concepts were rested for clarity, with precaution to not changing their meaning. Synonymous concepts and links were merged or created. Superordinate concepts were created and linked to subordinate concepts. And some concepts and propositions that were included in the Intermediate and/or Novice groups Composite Concept Maps were also eliminated, as these were regarded as simple or obvious. These "assessment" Concept Maps, then, were transformed into the assessment items, described next.

4.2 Multiple Choice Concept Map

The MCCM introduces the multiple-choice testing method into the context of a Concept Map. To our knowledge, this was the first such attempt to blend the strengths of Concept Mapping with the validity of the multiple-choice testing method, for learners of any type. The MCCM is unique in that it requires the test taker to consider an answer to a multiple-choice question with reference to the rest of the Concept Map. Importantly, the MCCM provides options of

We created two MCCMs, using CmapTools, which we present below. The two MCCMs dealt with (1) how the BLUFOR may appear to insurgents; and (2) how the local populace may provide indications of insurgent activity. Figure 6 was meant to assess the first area. For each proposition, a choice was provided for one of the concepts. Test takers were to select one of the provided answers (A or B) for each of the numbered items (1-5). For items 1 through 5, strings of propositions were included to provide additional context to consider.

presenting multiple choices at the concept, linking phrase, propositional and Concept Map levels. Essentially, any element within the Concept Map can be transformed into a multiple choice. The selection of elements for conversion into multiple-choice items may be suggested by the content of the Concept Map. False or distracting but relevant items may also be presented, which opens up finer scoring mechanisms. Most importantly, the MCCM is, at once, an assessment and a learning tool. As the test taker proceeds through the Concept Map, s/he is also attempting to understand the presented material in Concept Map form. Unlike the standard multiple-choice testing method, which presents questions serially, outside of any context, and provides little if any reinforcement of learning points, the MCCM requires the test taker to consider the entire learning experience while undergoing assessment.

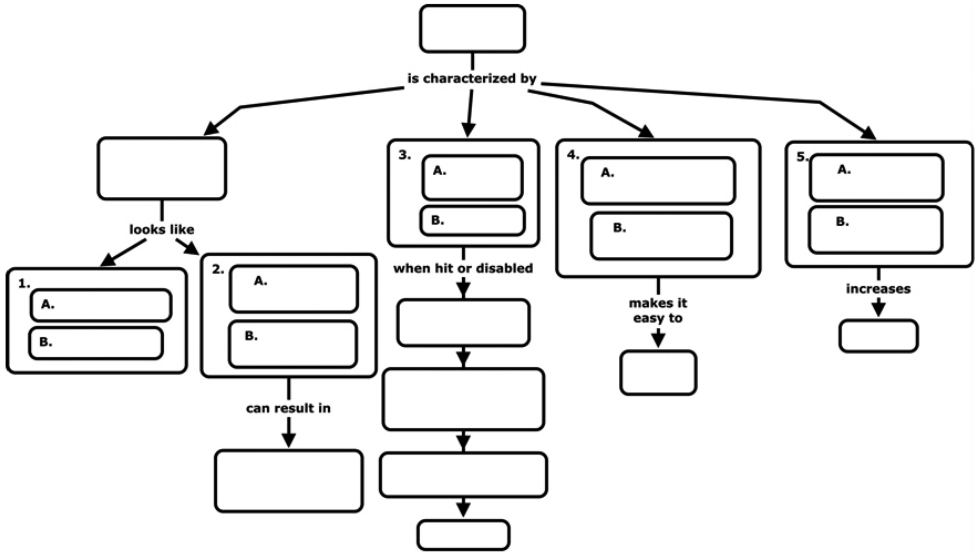


Figure 6. Multiple Choice Concept Map item example #1.

Figure 7 was meant to assess the second area. For each proposition, a choice was provided for one of the concepts. No strings were present. Test takers were to select one of the provided answers (A or B) for each of the numbered items (1-4).

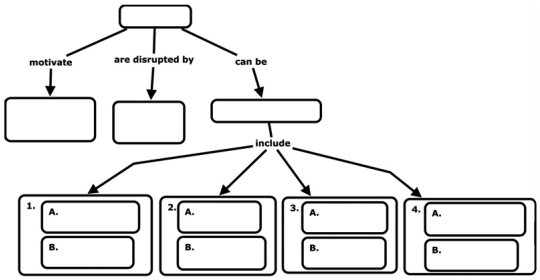


Figure 7. Multiple Choice Concept Map item example #2.

It is important to note that the structure of the MCCMs was suggested by the content of the assessment Concept Maps. For example, in Figure 6, the assessment content was a list of concepts that appeared at different levels of the Concept Map. The concepts suggested binary choices (e.g., on/off, fast/slow). Thus, these became the choices for selection. In Figure 7, however, the content was one to many relationships (i.e., one condition to many enablers). Thus, the structure of the MCCM was the single conditions linked to the multiple.

5 Stage 4: Use of the MCCM items

The MCCMs items were be used in July 2010 during a Test and Evaluation Exercise (TEE). The TEE involved eight military service member Participants, each with varying degrees of operational experience and familiarity with our training intervention. The TEE took place over the course of two days. On the first day, Participants took a Test (i.e., "PreTest"), then trained on the intervention. On the second day, Participants continued training on the intervention, then took the same Test again (i.e., "PostTest").

The MCCM items were included in a battery of 19 items (i.e., the "Pre/PostTest") provided to Participants via a custom-built, interactive assessment tool ("Tool"). Use of the Tool was already underway by the time we introduced the MCCM items; thus, implementation of the items was constrained to the capabilities of the Tool. However, the Tool also afforded capabilities that a not available in a CmapTools implementation—namely, the capability to blend the MCCM items with other types of assessment items and an ability to automatically record and compile answers. The MCCM items were item numbers 16 and 17 in the list, as shown in Figures 8 and 9. All other items were also multiple-choice, requiring selection of one or more answers in response to a stimulus, such as a picture or movie clip. To select answers on the MCCM items, Participants clicked on the correct concept. Figure 8 and 9 show this selection, with the correct concepts outlined in dashed lines, which is how they appeared to the Participants when selected.

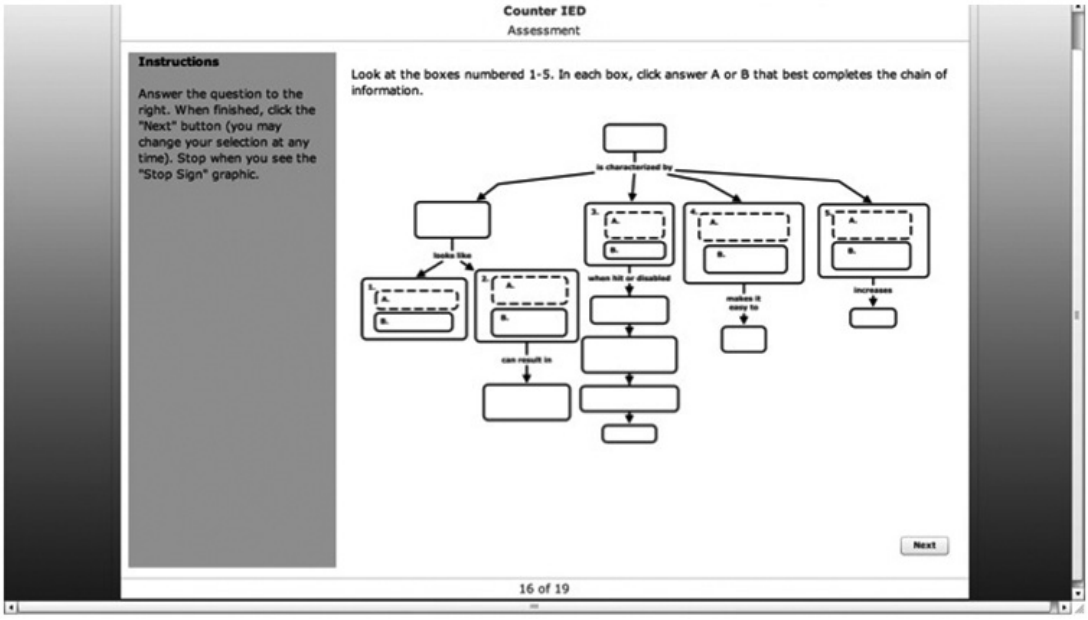


Figure 8. MCCM item example #1, embedded in the Tool.

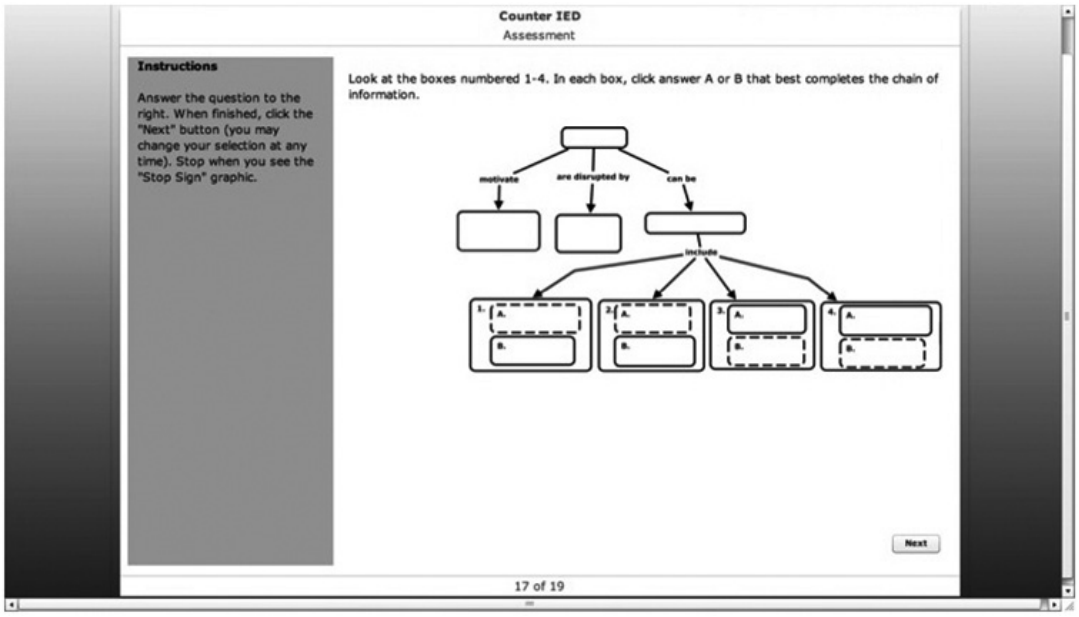


Figure 9. MCCM item example #2, embedded in the Tool.

6 Findings

While our overall effort was concerned with whether our training intervention demonstrated a capacity to change the Participants knowledge about IEDs, for the purposes of this paper we were primarily concerned with whether the MCCM items demonstrated capacity to detect changes in knowledge. We were also concerned with how the Participants responded to the MCCM items.

6.1 Outcomes of the MCCM items

The Participants' responses suggested that the MCCM items detected changes in knowledge. Table 2 presents the outcomes of the items. Correct answers (C) represent the selection of all of the correct concepts. Incorrect answers (I) represent selection of at least on incorrect concept.

MCCM item outcomes, by Participant	Item #16		Item #17	
	PRE	POST	PRE	POST
Participant 1	I	I	C	C
Participant 2	I	I	C	C
Participant 3	C	C	C	C
Participant 4	**I**	**C**	**C**	**C**
Participant 5	**I**	**C**	**I**	**C**
Participant 6	C	C	C	C
Participant 7	C	C	C	C
Participant 8	I	I	C	C

Table 2. MCCM item outcomes, by Participant

In particular, Participants 4 and 5 reflected changes in knowledge. Participant 4 selected one incorrect concept on Item #16 on the PreTest, but selected all correct concepts on the PostTest. Participant 5 selected two incorrect concepts on Item #16, and one incorrect item on Item #17, but selected all correct concepts on the PostTest. Also, for Item #16, Participants showed variance in their incorrect concept selections. That is, they did not all select the same incorrect concepts.

There were clear performance differences for the two MCCM items. For the combined PreTest and PostTest on Item #16, Participants were 50% correct. However, for the combined PreTest and PostTest on Item #17, Participants were 94% correct.

6.2 Observations on the use of the MCCM items

Regarding the Participants' response to the MCCM items, it was noteworthy during the PreTest that several Participants requested in support in answering the items. It was not clear to everyone what the question was requiring of them. One Participant's summed up the problem well in his request for support – he asked "Where is the question?" For some, it was also not clear how to record their answers. This observation was highly instructive, if not surprising. We expected that the MCCM items would present as an unfamiliar format. While we included instructions on how to fill in the answers, it was still not surprising that some Participants did not understand how to read or respond to "the question," particularly in light of the previous 15, standard multiple-choice items.

7 Summary and Discussion.

This paper reported on a four-stage approach for Concept Map-based assessment. Concept Mapping was used to identify knowledge differences between performers, and to hone in on areas of assessment of the differences. Concept Map-based assessment items—Multiple Choice Concept Maps—were developed based on the areas of assessment, and used in a demonstration event. The items were suggested to be sensitive to changes in knowledge.

We believe this paper provides a roadmap for future work in the area of Concept Map-based assessment. Given the limited scope, however, it can only be taken as suggestive. We suggest that future work may follow our four stages, and report on the efficacy of the approach. Future work should extend the stages. For example, additional research with the MCCMs will be necessary to determine heuristics for matching content to MCCM structure—e.g., one-to-many relationships, use of strings. Further research into the best practices for use of MCCM items is also called for. This research could consider how to best introduce the MCCM items, and also study when and how best to use MCCM items alongside other item types—i.e., do dramatic changes in the item types affect test taking. Also, it is not clear from our effort what the complexity thresholds for MCCM items might be. Clearly, the performance differences on the MCCM items suggested that Item #16 was more challenging than Item #17. This could be due to the difficulty of the content and/or a more complex structure involving strings. Research is necessary to tease these factors apart, and consider how MCCM items might introduce additional complexity with more strings, more concept choices, linking and even proposition choices. Finally, research could also directly compare MCCMs to standard multiple-choice items, on aspects of validity and reliability.

Of great importance in future research could be the development of software tools to directly support the development and use of Concept Map-based assessment items. CmapTools proved highly useful for our first two stages, and was useful in prototyping the MCCMs. However, additional computational capabilities will be necessary to enable creation, scoring, tracking and comparison of Concept Map-based assessment items. We expect to also use and examine other Concept Map-based items types for use in assessing adult learners. In particular, we believe the use of Select And Fill-In (SAFI) Concept Maps is appropriate for adult learners, as Stevens (1997) demonstrated and Schau (2001) confirmed. Our first and second stages will be necessary no matter the item type, as these stages are vital to the identification of areas of assessment. In the next phase of our research program, we will be experimenting with SAFI Concept Maps.

Finally, while we focused this paper on adult learners, in the course of our research we identified no reasons that suggested that our approach will be useful only for adult learners. Indeed, we hope to see the expansion of Concept Map-based assessment approaches in classrooms and other assessment environments where Concept Mapping is an established pedagogical technique. In the United States, Concept Map-based assessment approaches have already been "highly recommended") for inclusion in every National Assessment of Educational Progress Science Assessment at the 8th and 12th grade levels (WestEd and Council of Chief State Officers, 2008, p. 114; WestEd and Council of Chief State Officers, 2007, p. 171). In these contexts, our first and second stages will not be necessary, as the areas of assessment will already be identified. No doubt, much could be learned about our third and fourth stages—i.e., by

creating and using Concept Map-based assessment items. Hopefully, our contribution will be but one of many in the coming years.

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CONCEPT MAPPING AS LEARNING TOOL IN PROBLEM-ORIENTED LEARNING

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Abstract. In two studies we investigated whether concept mapping or summary writing is more effective in supporting students' learning from authentic problems in the field of business. We interpret concept mapping and summary writing as elaboration tools aiming at helping students to understand new information, and to integrate it with prior knowledge. We hypothesize concept mapping to be superior to summary writing because concept maps represent important information in a structured graphical manner consisting of nodes and relations between the nodes. In contrast, summaries are characterized by a linear order of information. Thus, it might be more difficult to recognize and express interdependencies. Both studies had a pre-test and post-test design with two experimental groups (concept mapping and summary writing). In the first study, 39 students of a commercial high school (pre-university level) in their next to last year took part. In the second study 17 students aged 16-18 years from the pre-final year of pre-university education participated. Contrary to our expectations, in both studies the summary writing group outperformed the concept mapping group. We attribute the results mainly to the fact that students are more familiar with summary writing than concept mapping and thus continuous training might have led to other results.

1 Introduction

According to situated learning theory (Collins, Brown, & Duguid, 1989), students learn both the domain knowledge and the discourse of the domain, when they have to solve authentic domain problems. While solving the problem, students learn domain concepts and problem solving itself (Kneppers, 2007; Kneppers, Elshout-Mohr, Van Hout-Wolters, & Van Boxtel, 2007). However, in schools, learning almost exclusively takes place on an abstract level. Consequently, application of concepts in daily life or in the workplace, and contextual reasoning will be difficult. Seen from these point of view authentic tasks which cover complex situations and ill-structured problems should be integral part of instruction.

Authentic tasks are often assigned to students using problem-oriented texts (Arzberger & Brehm, 1995). Problem-oriented texts confront students with an authentic case and require them to find a solution. In the course of this process, active learning takes place which support students in acquiring knowledge and applying it in new situations and to new tasks. However, learning from authentic problems resp. problem-oriented texts often leads to deficient results. Students have difficulty understanding main ideas and complex interrelationships of relevant topics. Consequently, they can not develop a structured knowledge base which is a prerequisite for problem-solving. Learning from problem-oriented texts can be facilitated by using specific learning strategies, especially elaboration strategies (Weinstein & Mayer, 1986). Elaborations go beyond the original texts because they are constructed by the learner independently. In the course of this process, the recipient activates his/her prior knowledge and combines it with text information. Thus, a rich knowledge base is generated (Christmann & Groeben, 1996, p. 145) which may result in better memory and better understanding of the material to be learned (Reder, 1980, p. 7f.). Concept mapping and summary writing can be regarded as two different elaboration tools.

Concept maps are two-dimensional structural representations of a topic consisting of nodes and labeled lines between the nodes. The nodes represent important concepts; the lines are relations between the concepts. The combination of two nodes and a labeled line in between is called a proposition. A proposition is a basic semantic unit which can be assessed true or false (Ruiz-Primo & Shavelson, 1996). The original version of concept maps as used by Novak (1990) demands a hierarchical structure. But, dependent on the respective question, in many studies concept maps are used in a more flexible way. O'Donnell, Dansereau, and Hall (2002) use the expression knowledge map instead of concept map. Knowledge maps, in their opinion, consist of a fixed set of relations. In the process of concept mapping students translate text information into a visual format which displays the main ideas and their interrelations. As a

prerequisite, students have to recognize the important concepts and decide about their interrelationships. This is an active and reflective process which leads to elaboration (Beyerbach & Smith, 1990).

Similar to concept maps, summaries have the function of consolidating text information in a macrostructure (van Dijk, 1980). In the process of summary writing, students have both to select important and to omit irrelevant concepts, they have to aggregate propositions, and they have to construct propositions which do not or not identically exist in the text (Christmann & Groeben, 1996). Thus, summary writing like concept mapping is an active and reflective process. The most important difference between the two strategies is the format. While concept maps represent information in a structured graphic, summaries represent information in a linear order.

Concept maps are assumed to be advantageous for displaying all relations between concepts in an unequivocal manner. In contrast, summaries contain the relations between the main concepts in several sentences, and the universe of interrelationships as well as potential hierarchies might not be as clear as in the graphic (Nesbit & Adesope, 2006). The decisions about the information structure do not necessarily be as precise as in the concept map. Furthermore, concept maps can be regarded as specific pictures which contain both verbal and pictorial information. According to dual coding theory (Paivio, 1986), visuo-spatial and verbal information have to be processed in different channels at the same time. This might lead to deeper and more efficient information processing than working exclusively with verbal data. The parallel processing takes place while translating maps into texts.

In a couple of studies concept mapping proves to be an effective learning-from-text strategy. Amer (1994), for example, shows that both, translating a scientific text into a knowledge map and underlining important information in a scientific text is superior to just reading a text. However, no significant differences could be found between concept mapping and underlining. Further more, Nesbit and Adesope (2006) report in their meta-analysis that concept mapping only has a small advantage compared to other construction tasks like note taking or summary writing. Against this background the aim of our research is to investigate whether concept mapping or summary writing is more effective for promoting students' learning from authentic problems in the field of business. For that purpose, we conducted two studies using the same material, one in Germany and one in the Netherlands.

2 Study 1: Concept Mapping vs. Summary Writing as Learning Tools in Problem-Oriented Learning of Individuals

2.1 Research Question and Hypothesis

Research Question: Is concept mapping more effective than summary writing for promoting students' learning from authentic problem-oriented texts?

Hypothesis: Concept mapping is superior to summary writing.

2.2 Learning Material

We developed an authentic case (see Figure 1) which should support students in learning different forms of financing. In addition, we provided the students with learning material consisting of data about the case and information necessary for solving the problem.

2.3 Method

2.3.1 Participants and Intervention

39 students of a commercial high school (pre-university level) in their next to last year took part in the study during the school year 2009/2010. They were 18.3 years old on average. All students had prior knowledge about management

Taxi firm *Speedy Rite* is a one-mans' business. The owner, Mister Simons, is also the manager. The firm possesses 6 cabs. All cabs are from trademark Cicerro. Two of the cabs are 6 years old, two 4 years and two are 2 years old. The economic working life of the cabs is 6 years, so two of the cabs have to be replaced. Until now Simons has bought all new cars by a bank loan. He is wondering, however, if it is wise to continue that habit now during the financial crisis. Besides, he is asking himself if the bank is willing to give him a loan again. Simons considers if he is better off leasing the cabs. But, unfortunately, he is not capable of deciding about which form of financing will best meet his needs. And, he does not understand the meaning of the two different forms of leasing – financial and operational – and the consequences they will have for his business.

Therefore, he is asking you for help.
Figure out what is best for Simons: buying the cabs with a bank loan or leasing the cabs: financial or operational. The advice you will give Simons has to be reported in a clear manner. You have to make clear all the steps you have undertaken to come to the advice.

Figure 1. Authentic Case

but not about forms of financing. The students were randomly assigned to one of two experimental groups, i.e. either concept mapping or summary writing. We further divided the concept mapping group into a paper and pencil group on the one hand and an IHMC CMapTools (Cañas et al., 2004, http://cmap.ihmc.us) group on the other. All students had to work through the learning material (see Figure 1) and in addition construct a concept map or write a summary on the relevant information. As an aid every student received a list of concepts. In addition, the students of the concept mapping groups received a list of relations. A day before starting the study, we put the respective strategy across to the students by means of two familiar topics (the notion of a flower and the individual prospect of vacation).

2.3.2 Data Gathering

Before and after the treatment the students took a knowledge test consisting of nine tasks in short answer or essay format (see Figure 2). Questions in multiple-choice format were not included. The test is constructed in parallel forms A and B. In order to control the learners' verbal abilities we applied two subtests (analogies and concept meaning) of the WIT-2 (Wilde Intelligence Test-2) (Kersting, Althoff, & Jäger, 2008).

2.3.3 Data Analysis

The students' answers were analyzed using a qualitative content analysis procedure. This is a systematic, replicable technique for assigning words or phrases of a text to content categories based on explicit rules of coding. The coefficient for the intercoder reliability ($\rho = .962$, $p = .000$) underscores the reliability of the category system. On the basis of the qualitative content analysis a test score was calculated for each student. To determine whether the groups differ in knowledge, a two-way mixed analysis of variance was carried out with "group" as between-subjects factor (independent) and "time" as within-subjects factor (dependent). The calculation was based on the raw scores. We did not analyze difference scores. In addition, effect sizes were determined. We used the measure "d" as effect size which is calculated as difference of means between the groups divided by the standard deviation. For our pre-test – post-test design we used corrected effect size dcorr which is determined by subtracting pre-test from post-test effect size. In hat case the pooled standard deviation of the respective groups was used as standard deviation (Klauer, 1993, S. 58).

2.4 Results

In terms of test scores, the concept mapping paper and pencil group had lowest prior knowledge (6.5 points), but the highest increase in knowledge (5.3 points or 80%), the CMapTools group scored second best in the pre-test (8 points), but reached the lowest increase in knowledge (2.6 points or 33%). Finally, the summary group had the highest prior knowledge (8.4 points) and achieved the second best result in knowledge increase (4.5 points or 52%) (see Table 1).

The two-way mixed ANOVA showed a main effect for the factor time ($F = 42.209$; $p=.000$), indicating a significant increase in knowledge over time for all groups. However, the interaction effect time * group shows that the groups did not differ significantly in their knowledge increase from pre-test to post-test ($F = 1.431$; $p = .252$). The

effect size with regard to both concept mapping groups versus summary group (dcorr = -.027) is close to zero which means that concept mapping at large, that is to say disregarding the two techniques, and summary writing do not differ in supporting students' learning processes. The algebraic sign "minus" indicates in this case a slight advantage of summary writing over concept mapping. The effect size with regard to concept mapping paper and pencil versus concept mapping CMapTools (dcorr = .767) is at least remarkable. Thus, concept mapping by means of paper and pencil is by trend, though not significantly, superior to concept mapping by means of CMapTools (see Table 2).

	Cmapping Paper & Pencil (N=14)		Cmapping CmapTools (N=11)		Cmapping (both groups) (N=25)		Summary (N=14)	
	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)
Pre-test	6.5	(3.7)	8	(2.7)	7.3	(3.2)	8.3	(2.1)
Post-test	11.8	(3.9)	10.7	(3.4)	11.3	(3.6)	12.7	(3.6)
Gain	5.3	4.6	2.6	3.3	4	4	4.4	(3.6)

Table 1. Results of Pre- and Post-Test: Means and (Standard Deviations)

Source	SS	df	MS	F	p	d_{corr}
group	29.633	2	14.816	1.040	.364	
time	322.5	1	322.5	42.209	.000	
group * time	21.871	2	10.936	1.431	.252	Cmap(both) – summary: -.027 Cmap(P&P) – CmapTools: .767

Table 2. Analysis of Variance (Basis: Raw Test Scores of the 3 Groups)

Concerning the verbal abilities, the groups did not differ significantly. The summary group had the highest mean score, followed by the concept mapping CMapTools group, and the concept mapping paper and pencil group. No significant correlation between verbal abilities and knowledge increase could be found.

The Cronbachs' alpha for the post-test was .422, and for the pre-test only .385. Thus, due to high variances concerning some questions, the internal consistency of the tests is very low.

3 Study 2: Concept Mapping vs. Summary Writing as Learning Tools in Problem-Oriented Learning of Dyads

3.1 Introduction

This study differs in some way from the first study. The first study was comparing text writing and concept mapping for individual learning. However, many studies stated that collaboration is effective for learning. Chi (2004) and Roychoudhury (1993, 1994) conclude that concept mapping in collaboration can lead to effective discussions about concepts. That supports learning. Roth and Roychoudhury (1992) are seeing collaborative concept mapping as an activity that contributes to the development of the discursive practice. Concept mapping is a good way to force students to communicate in a scientific manner. Students become, as they call it, members of a community of knowledge and practice. They learn strategies to negotiate in domain language and to practice them in the domain usual communication forms. This type of interaction is described in literature as explorative talk (Mercer & Wegerif, 1999) and construction and reconstruction (Dekker & Elshout-Mohr, 1998).

3.2 Research Question and Hypotheses

Research Question: Which learning strategy, concept mapping or summary writing, is better for the learning of conceptual knowledge in an authentic problem solving task in the field of Business Science?

Hypothesis: Concept mapping supports better the acquisition of conceptual knowledge while solving a problem.

3.3 Design

In the Netherlands, the study was designed as a pre-test and a post-test experiment with two experimental conditions: the concept mapping condition and the summary writing condition. The experimental conditions are the independent variable. The dependent variable is the conceptual knowledge. Students were randomly assigned to the two conditions. The pre-test was, besides to compare the results with the post-test, administered to control whether groups differ in prior knowledge.

Students were working in pairs. Pairs were formed by use of the 'middle group-method' (Pijls, Dekker, & Van Hout-Wolters, 2003). This method resulted in pairs that were somewhat, but not extremely heterogeneous.

3.3.1 Participants and instruction

17 students aged 16-18 years from the pre-final year of pre-university education participated in the study. They are attending a three years course called Management and Organization beside other economic and general education. The students were in their second year. The subject chosen for the experiment – forms of financing - had not been taught before but is part of the regular curriculum at school.

The total research period covered five lessons; two for instruction and three for testing, practicing concept mapping with the software CmapTools (http://cmap.ihmc.us) respectively writing a summary on a computer. All students were experienced workers with word processing but not familiar with a concept mapping program. In the first lesson the students took a verbal ability test and practiced concept mapping or summary writing using the respective programs on a computer. In the second lesson the students took a knowledge test. In the third and forth lesson students were working on the learning material. Finally, the students performed a post-test in the fifth lesson.

3.3.2 The learning material

The students of the concept mapping condition got the case (see Figure 1) they had to solve. They were requested to construct a concept map as a tool for solving the problem. We gave them three concepts: bank loan, operational leasing, and financial leasing. They had to include all related concepts needed to solve the problem, and to describe the relations. First, they worked individually using paper and post-it'sTM. After that they had to compare their work in pairs. Then they received the learning material – information - to work out their individually made maps into one joined constructed map on the computer. Because they had to reach consensus about the map, discussion was required. In the second lesson, the students had the task to make a substantiated decision for the case: the specific situation of Simons. The writing condition followed the same procedure. Instead of concept mapping they were writing.

3.3.3 Tests

A verbal ability test, called WIT-2 (Wilde Intelligence Test -2) (Kersting, Althoff, & Jäger, 2008) was performed by the students. In addition, the students took knowledge tests as pre-test and post-test. Pre-test and post-test consisted of tasks concerning knowledge about bank loan and leasing. The test is constructed in parallel forms A and B. An example of a question can be seen in Figure 2.

Your firm will buy a new internet server with a value of € 8.450,00. You are responsible for the financing of this server. You got the following offers:

Financial Leasing

- Duration: 3 years
- Leasing amount per year: 3.380,00 €
- Option after end of the contract: ongoing rent against 305,00 € per year
- Total amount: 10.140,00 € (after 3 years)

Operational Leasing

- Duration: 3 years
- Leasing amount per year: 4.754,00 €
- Total amount: 14.262,00 € (after 3 years)

The following details about the firm are known:

Solvency percentage on this moment: 162%

Solvency percentage if chosen for Financial Lease: 187%

Solvency percentage if chosen for Operational Lease: 162%

Please decide in favour of one of the offers and give reasons for your decision!

Figure 2. Example of a task in pre-test and post-test.

3.4 Results

At the start of the experiment there appeared to be no significant difference in the results of the pre-test ($t = -.12$; $df = 15$; $p = .91$). To determine whether differences in knowledge increase between the pre-test and the post-test that could be explained by concept mapping or summary writing, an Anova covariance analyses (controlled by the pre-test) was performed. We expected that the concept mapping condition should perform better on the post-test, but it did not ($F(1,14) = 10.829$; $p = .005$). The writing condition performed even better. This result was reaching significance.

	Concept mapping condition (N=8)		Writing condition (N=9)		Max. score	Highest score
	Mean	(SD)	Mean	(SD)		
Pre-test	.2031	(.1123)	.1991	(.0950)	.24	.33
Post-test	.3221	(.1765)	.3782	(.1490)	.26	.62

Table 3. Scores for concept mapping and writing condition: means and standard deviations (in brackets)

From a t-test for paired-sampled test we learned that on the post-test, the mean scores were significantly better than on the pre-test (M/SD pre-test = .20 (.10), M/SD post-test = .35 (.16) ($t = -2.663$; $df = 16$; $p = .000$). The students improved their knowledge.

The Cronbachs' alpha for the post-test was .61, which is not high enough. The alpha of the pre-test was, however that is usual for a pre-test, even lower 23.

4 Conclusions

The learning strategies concept mapping and summary writing support the students' learning from problem-oriented text. In both studies, the knowledge of all groups about forms of financing improved significantly from pre-test to

post-test. This result is consistent with other studies according to which active involvement in knowledge construction, e.g. by the learning strategies such as concept mapping or summary writing, fosters learning. In addition, the results underline once more the meaning of learning strategies or learning tools.

However, the initial hypothesis in both studies has to be rejected. In both studies, summary writing is advantageous to concept mapping. In the second study the writing condition is even significantly better than the concept mapping condition.

The results of both studies may be attributed to the comparatively new format for knowledge explication which is required by concept mapping. The students may not be familiar enough with the technique so that they cannot apply it confidently. Instead, the students may much more be used to summary writing. Continuous training in concept mapping previous to the study might have led to other results. However, this interpretation has to be – at least partly – revised if we regard the two concept mapping formats used in study 1 separately. The study shows that concept mapping using paper and pencil is by trend superior to summary writing whereas summary writing is by trend superior to concept mapping using CMapTools (see effect size contrasting the concept mapping paper and pencil group and the concept mapping CMap Tools group, and descriptive statistics). For the results did not reach significance, further research is needed, here. At this point, we are only able to utter some speculations. The superiority of concept mapping using paper and pencil may be explained by its graphical features. As two-dimensional diagrams concept maps may better facilitate the understanding of the macrostructure of information than linear texts. The inferiority of concept mapping using CMapTools may be attributed to the fact that working with the computer is more time consuming and causes more extraneous cognitive load (Sweller, 1988) compared to paper and pencil. Thus students concentrate more on handling the computer than on structuring the contents. Furthermore, the comparatively small size of the monitor constrains the possibility of keeping an overview over the complex topic of forms of financing. In a feedback discussion, some students remark that the haptic experience of using paper and pencil supports thinking. More training in using CMapTools may lead to other results.

In our future research we will train the CMapTools group more intensively. Further more, it would be interesting to systematically contrast computer use with paper and pencil use and analyze whether the results of study 1 could be replicated using a greater sample. In addition, we will include a control group in the study which does not use any learning strategy but exclusively read the learning material. By this means, we will be able to identify the effect of the additional learning strategies.

With regard to problem solving, we have to think about more structuring the problem solving process. Students know were struggling with that because they were not enough trained in problem solving strategies. That may be having influenced the results in concept learning. We will also partly revise the tests. The internal consistencies of the tests were very low.

Because these studies were pilots to try out different approaches, we have to consider which of the now performed approaches we will put on a larger scale for the following study.

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Concept Maps: Making Learning Meaningful
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CONCEPT MAPPING FOR PLANNING AND INSTRUCTION IN A CHILDCARE SETTING

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Abstract. The purpose of this paper is to detail the processes and procedures for incorporating concept mapping into instructional planning and implementation in four classrooms in a childcare setting (n=32). Nonfiction books and hands-on materials were used to build children's background knowledge and vocabulary in the health domain. Assessments at three points during the instructional period provided information that could be used to focus instruction. Concept maps were created based on interviews with the children. The maps were then scored by staff experienced in the scoring protocol validated previously by institute staff. Results of analyses indicated that Assessment 1 vocabulary was correlated to the final assessment results. Discussion of findings and recommendations for further research are presented.

1 Introduction

Recent research has focused on the importance of definitional or academic vocabulary in improving children's background knowledge and reading comprehension (Hirsch, 2006; Neuman & Celano, 2006; Marzano, 2004; Beck, McKeown & Kucan, 2002). In addition, it has been posited that explicit instruction in vocabulary must begin in early education years to combat the academic achievement gap that has persisted as children of poverty progress through primary education years. The achievement gap has manifested itself in what has been called "fade out" by grade three (Hirsch, 2003; Kauerz, K., 2006)

Over the past several years, staff at a research institute in the southeastern United States has developed and implemented two units of instruction for 3- and 4-year-old children who live in high-needs neighborhoods. The units focus on introducing science content by using nonfiction books. Through informational texts, the children have been taught basic science concepts related to plants and butterflies in one unit and health in the other. Another aspect of using informational texts is to enable teachers, many of whom do not have a college degree, to acquire basic understanding of the informational content. Concept mapping has been used to help the teachers plan the instruction and focus on the importance of using advance organizers to facilitate young children's knowledge acquisition in science (Zimmerman, 2005). Concept maps have also been used to enable the children to make connections among the concepts being taught and to assess their understandings (Figueiredo, M., Lopes, A. S., Firmino, R., & deSousa, S., 2004).

This paper details the processes and procedures used to implement a health-related unit of instruction during Spring 2009 in four classrooms in an urban childcare setting. Results of analyses and samples of concept maps of the children's interviews are presented.

2 Goals

The focus of the *Encouraging Healthy Habits through Literacy (Healthy Habits)* unit was to use a three-prong approach to combat the rise in childhood obesity/overweight through prevention, intervention, and community outreach activities. The program was designed to address three goals: 1) improve students' overall physical status (physical fitness), 2) improve students' overall nutritional status (nutrition education), and 3) improve families' understanding of nutrition education and physical activities to combat childhood obesity (family education).

3 Research Questions

To address the effectiveness of the planning and instructional activities, institute staff designed an assessment protocol

similar to that of Figuerdo et al. (2004). Assessment 1 was an expressive vocabulary measure using pictures related to being healthy as items. Assessment 2 used an open-ended question (without visual prompts) asking children to express what they knew about being healthy. Assessment 3 was the same open-ended question used in Assessment 2, but the child was provided a visual prompt, the class concept map. Research questions included the following:

1. Do Assessment 2 scores correlate with Assessment 3 scores?
2. Is there a difference between the Assessment 2 scores of 3-year olds and 4-year on?
3. Is the Assessment 1 score predictive of Assessment 2 score?
4. Is the Assessment 1 score predictive of Assessment 3 score?

4 Methodology/Approach

4.1 Teacher Training

Institute staff provided a training session for the childcare teachers (n=4) to acquaint them with the procedures for creating concept maps. Sample concept maps were shared and discussed with the teachers. Relevant pictures were provided to facilitate the construction of class concept maps. Teachers' initial concept maps were more generalized nonlinguistic representations, like descriptive pattern organizers and concept pattern organizers (Marzano, R. J., Pickering, D. J., & Pollock, J. E., 2001). These representations did not include propositions or a hierarchy.

Assisting childcare staff in constructing concept maps that include propositions involved a scaffolded process. For example, staff members were shown video clips of (a) a teacher engaging young children in conversations about a focus concept by posing a focus question and then using pictures to represent the connections expressed by the children, and (b) a teacher using post-it notes to capture the concepts named by the children during a classroom discussion. Institute staff was on site to assist with this process. In addition, the basic strands of the concept map that was created using the relevant pictures were enlarged to facilitate class discussions among the teachers and children (Figure 1).

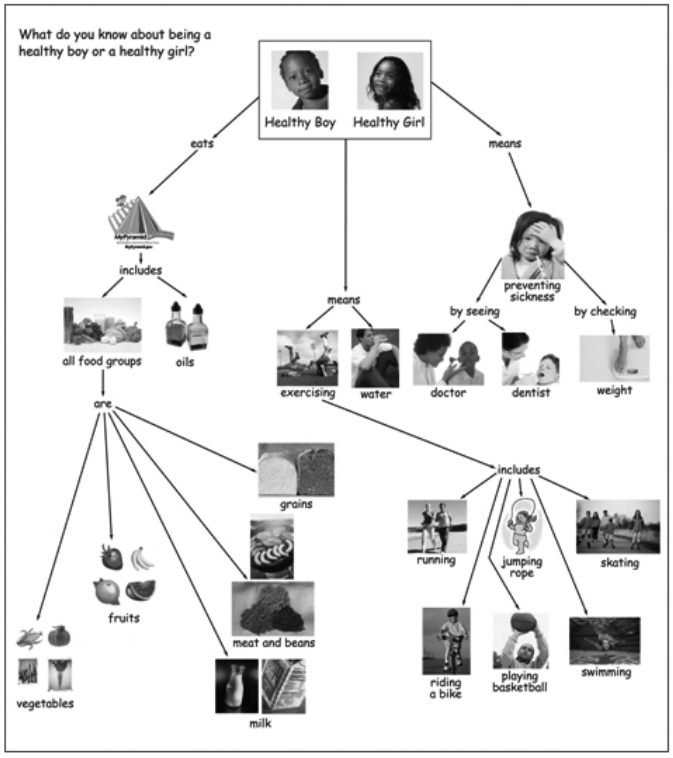


Figure 1. Healthy Habits concept map.

4.2 Components of the Curriculum

The core curriculum used was *Color Me Healthy*, developed at North Carolina State University in cooperation with the North Carolina Cooperative Extension agency and the North Carolina Division of Public Health. *Color Me Healthy* consists of 14 lessons to develop children's understanding of the importance of diet and exercise in maintaining a healthy weight. To enhance the curriculum, institute staff identified relevant and appropriate nonfiction books and lesson extensions to accompany the *Color Me Healthy* curriculum. Additionally, movement DVDs were created that correlated to the content of the curriculum.

Implementation at an urban childcare center began in January 2009 with the teacher training component. During the training, teachers were provided with the Color Me Healthy curriculum kits, sets of nonfiction books on nutrition, and the lesson plan format that had been revised from a partial implementation at another urban childcare center. They also received materials for hands-on activities, e.g., plastic foods for sorting and grouping, parachute for exercise, food pyramid pocket chart and cards, etc. Project implementation was scheduled for February 23 through April 30; however, the ending date was moved to June 12 because of other curriculum needs.

4.3 Assessment

The project director provided on-site assistance on a regular basis by attending most weekly teachers' meetings with the center's director. Additionally, the project director conducted assessments as follows: 1) Assessment 1 (late February and early March); 2) Assessment 2 (mid June); and 3) Assessment 3 (late June). In Assessment 1, the children (n=32) were given pictures of children engaged in various activities as well as pictures of food and medicine. The prompt for them to tell what they knew about the pictures was, "Tell me what you know about being healthy." For Assessment 2, children were not provided any pictures to stimulate their thinking. Their prompt was the following, "Think about the pictures and books Ms. has read and discussed about being healthy. Tell me what you know about being healthy." This assessment was designed to examine connections children were able to make about the concepts that had been taught without pictures to prompt their thinking. Samples of maps and scores from both age groups appear in Figure 2.

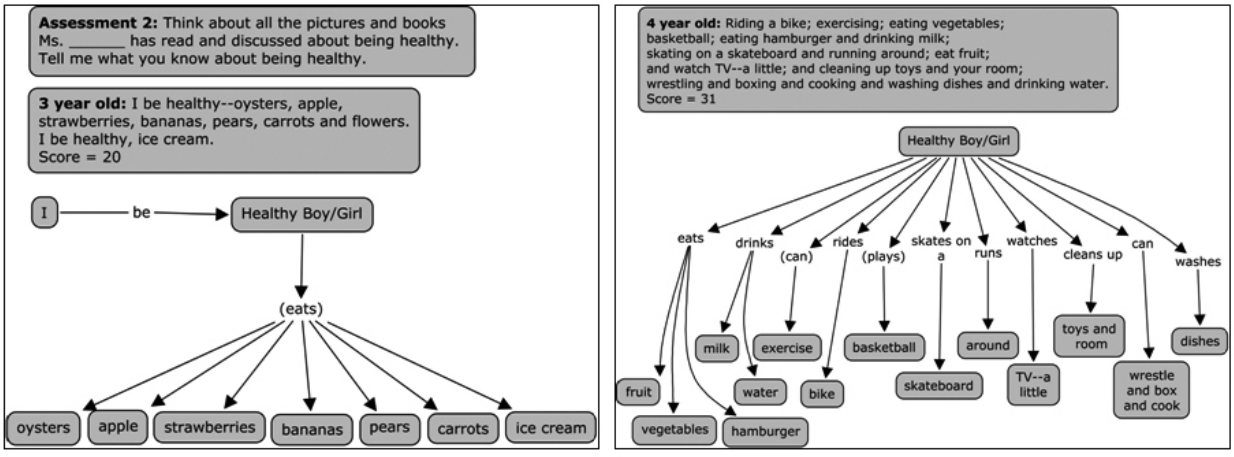
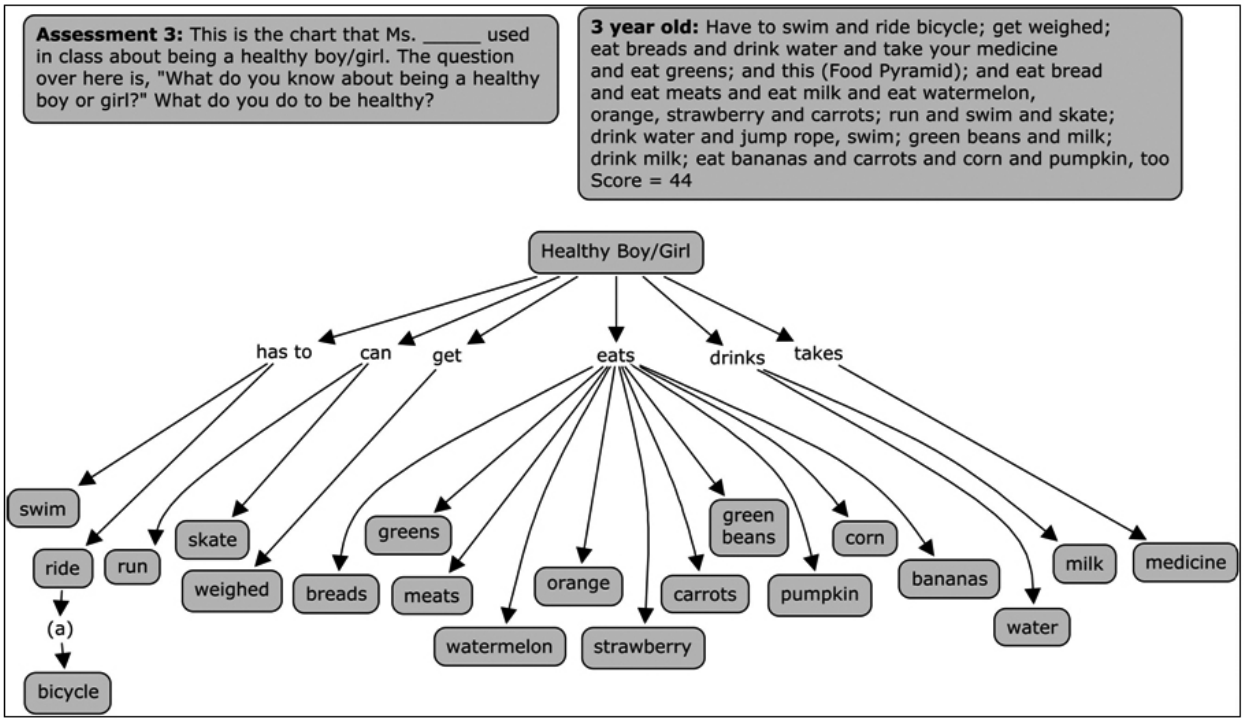


Figure 2. Assessment 2 concept maps for 3- and 4-year old children. (Concept maps were created from children's interviews.)

For Assessment 3, the children were provided the class concept map and the prompt, "This is the chart that Ms. used in class about being a healthy boy/girl. The question over here is, 'What do you know about being a healthy boy or girl?' What do you do to be healthy?" This assessment protocol was adapted from Figuerdo et al. (2004). Assessment 3 scores were used to compare the children's concept connections with and without the concept map to stimulate their thinking. Samples of maps from both age groups appear in Figure 3.



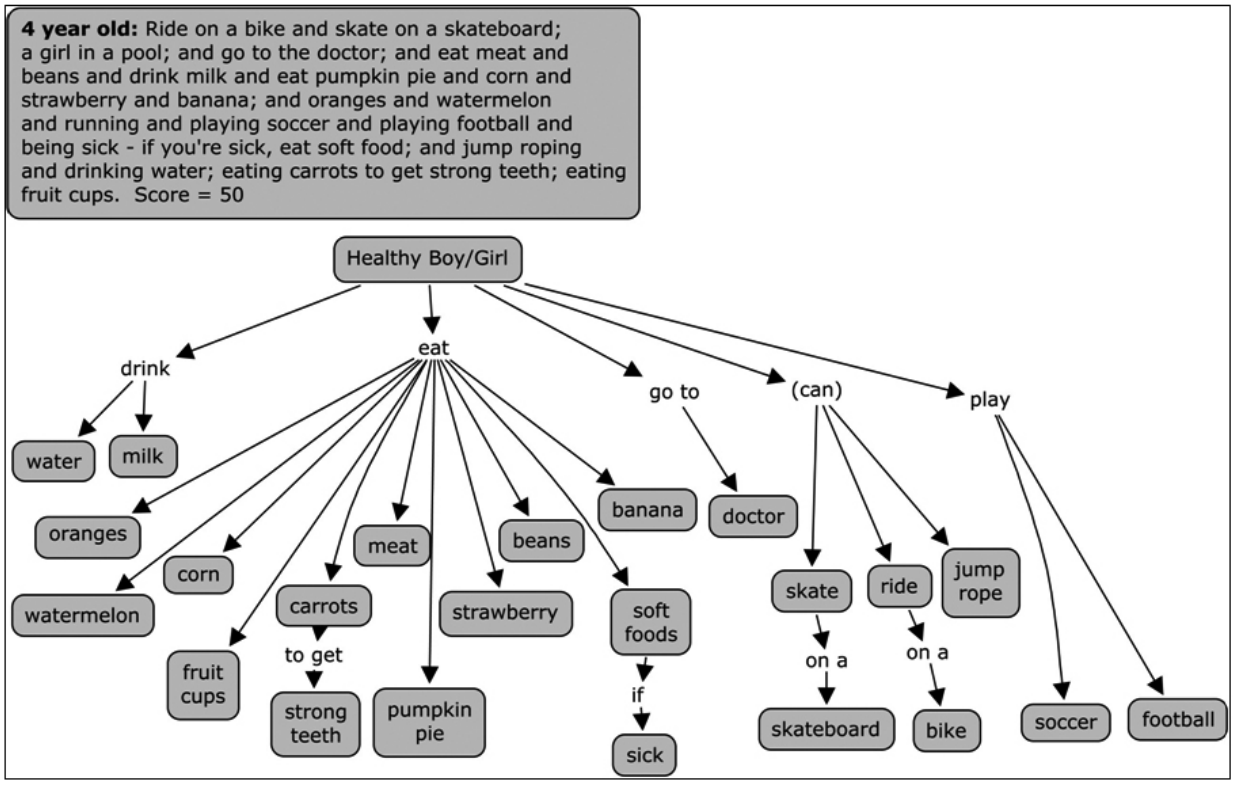


Figure 3. Assessment 3 concept maps for 3- and 4-year old children.

5 Results

Project researchers interviewed individual children and transcribed their responses. Concept maps were constructed from the transcripts by researchers experienced in reliably creating and scoring concept maps from interview transcripts (α=.95; Wehry, Algina, Hunter, & Monroe-Ossi, 2008). See Figure 4 for an example of constructing concept maps and scoring them.

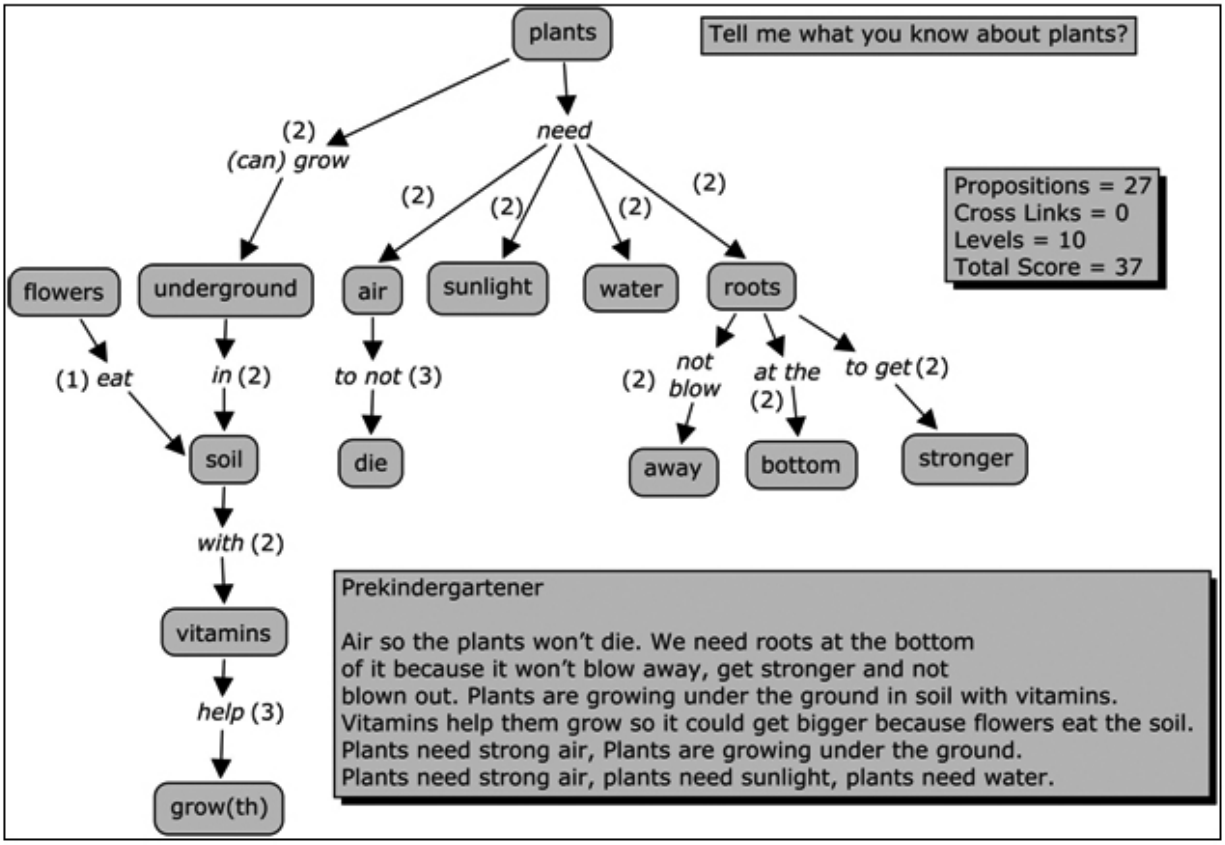


Figure 4. Example of a child's interview, the subsequently constructed concept map, and concept map score

Analysis of the concept maps to determine the number of strands mentioned by the children revealed that ten 3-year olds cited only one strand—either food (n=9) or exercise (n=1) during Assessment 2 (See sample map in Figure 2). However, at Assessment 3, with the class concept map for support, eleven 3-year olds (64%) made connections about the three major strands (food, exercise, and wellness); six of those children were also able to make the connection to the need to drink water as a factor in being healthy (Table 1).

In contrast to the results for 3-year olds, the strand analysis for 4-year olds revealed that on Assessment 2, nine children were able to cite connections about two or more strands without the aid of pictures (See sample map in Figure 2). With the class concept map for reference, 11 children (73%) were able to make connections about the three major strands; eight of those also identified the need for water, especially when exercising (Table 1).

	Number of Responses			
	3-Year Olds (*n*=17)		4-Year Olds (*n*=15)	
	Assessment 2	Assessment 3	Assessment 2	Assessment 3
Food (F)	9	0	5	0
Exercise (E)	1	0	1	0
F and E	1	3	2	1
F and Drink (D)	3	0	4	0
F and Wellness (W)	2	0	0	0
F,E, and D	0	3	2	3
F,E, and W	1	5	0	3
F, W, and D	0	0	1	0
F, E, W, and D	0	6	0	8

Note. F = Food; E = Exercise; D = Drink; and W = Wellness

Table 1. Strands (Food, Exercise, Drink, and Wellness) Mentioned by 3- and 4-Year-Old Children at Assessments 2 and 3

The mean scores of the children on the various assessments revealed that in all cases, prekindergarten children, on average, scored higher than 3-year-old children. The 4-year-old Assessment 3 scores ranged from a low of 24 to a high of 74 points. The scores for 3-year olds ranged from a low of 17 to a high of 58 points (See Table 2).

Time	*n*	*M*	*SD*	*Min*	*Max*
Assessment 1					
All	33	7.45	6.63	0.00	22.00
4-Year Olds	16	11.88	6.23	2.00	22.00
3-Year Olds	17	3.29	3.69	0.00	14.00
Assessment 2					
All	33	29.33	14.59	2.00	61.00
4-Year Olds	16	36.56	15.17	12.00	61.00
3-Year Olds	17	22.53	10.42	2.00	41.00
Assessment 3					
All	32	40.94	12.05	17.00	74.00
4-Year Olds	15	45.20	13.93	24.00	74.00
3-Year Olds	17	37.18	8.90	17.00	58.00

Table 2. Summary Statistics for Assessment 1, Assessment 2, and Assessment 3

5.1 Results: Research Question 1: "Do Assessment 2 scores correlate with Assessment 3 scores?"

To address Research Question 1, a correlation analysis was conducted (See Table 3). As expected, assessments at each time were correlated with assessments at the other times. However, not expected was that Assessment 3 was more highly correlated with the Assessment 1 (.63) than with Assessment 2 (.46) which occurred closer in time.

	Assessment 2	Assessment 3
Assessment 1	.44 (*.01*)	.63 (*<.01*)
Assessment 2		.46 (*<.01*)

Note. Italicized numbers are *p*-values.

Table 3. Correlations of Assessment 1, Assessment 2, and Assessment 3

5.2 Results: Research Questions 2 and 3: "Is there a difference between the Assessment 2 scores of 3-year olds and 4-year olds?" and "Is the Assessment 1 score predictive of Assessment 2 score?"

Our Analysis of Variance (ANOVA) statistical model explained 25% of the total variance in the Assessment 2 scores. In this model, we tested the hypothesis that the Assessment 1 and the children's age determined by their placement in preschool or prekindergarten class were not predictive of the Assessment 2 score. The 3-year-old children scored, on average, 10 points less on Assessment 2 than did 4-year-old children (See Table 4). The children's Assessment 1 ability to describe pictures did not predict their ability to recall information and form propositions without the aid of visual clues.

	Estimate	*Standard Error*	*t*-value	*p*-value
Intercept	31.30	6.33	4.94	<.001
3-Year Old	-10.23	5.98	-1.71	.098
Assessment 1	0.44	0.45	0.97	.341

Table 4. ANOVA Results for Assessment 2

5.3 Results: Research Question 4: "Is the Assessment1 score predictive of Assessment 3 score?"

To address Research Question 4, we began with a simple ANOVA model that included only the Assessment 1 and the children's age as 3-year-old preschoolers and 4-year-old prekindergarteners as predictors. As expected, based on the estimated correlations shown in Table 3, the Assessment 1 was predictive of the Assessment 3 scores, and when controlling for initial achievement, the preschooler's mean score was almost three points higher than the prekindergarteners' mean score. To more fully address the Research Question, we added Assessment 2 scores and possible interactions to the model. The final model explained 55% of the total variance in the Assessment 3 scores (See Table 5).

	Estimate	*Standard Error*	*t*-value	*p*-value
Simple Model				
Intercept	29.88	4.81	6.22	<.001
3-Year Old	2.79	4.48	0.62	.539
Prekindergarten	0.00			
Assessment 1	1.37	0.37	3.73	<.001**
Final Model				
Intercept	14.19	6.72	2.11	.044
3-Year Old	19.16	8.10	2.37	.026
Prekindergarten	0.00			
Assessment 1	1.27	0.33	3.84	<.001**
Assessment 2	0.48	0.16	3.04	.005
3-year* Assessment 2	-0.49	0.26	-1.90	.069*
PreK*Assessment 2	0.00			

Note. *$p < .10$. **$p < .01$.

Table 5. ANOVA Results for Assessment 3

Results of the final model indicate that the main effect of Assessment 1 score was not involved in an interaction; therefore, the straight-forward interpretation of the results is that every word identified at Assessment 1 predicts a 1.27 increase in the Assessment 3 score. The main effect of Assessment 2 and the child's placement as 3- or 4-year-old is confounded (p-value = .069); therefore, interpretation of the simple main effects could be misleading. The results in the table indicate the following equations for predicting Assessment 3 for prekindergarten and preschool children.

$$\text{Assessment 3} = 14.19 + 1.27(\text{Assessment 1}) + 0.48(\text{Assessment 2})$$

for 4-year-old children, and

$$\text{Assessment 3} = 14.19 + 19.16(1(\text{for 3-year-olds})) + 1.27(\text{Assessment 1}) + 0.48(\text{Assessment2}) - 0.49(\text{Assessment2})$$

for 3-year-old children.

The equation for the 3-year-old children simplifies to

$$\text{Assessment 3} = 33.35 + 1.27(\text{Assessment 1}) - .01(\text{Assessment 2})$$

Thus, for children with the same Assessment 1 score, when the 3- and 4-year olds' Assessment 2 score is near zero, the 3-year olds' Assessment 3 score is 19 points higher than that of the 4-year olds'. However, the difference between 3- and 4-year olds' Assessment 3 score decreases as the Assessment 2 score increases, and when the Assessment 2 score of both groups of children approaches 38, there is no difference in the Assessment 3 score of preschool and prekindergarten children who have the same Assessment 1 score.

6 Summary

Data analyses indicated that Assessment 1 was more highly correlated with Assessment 3 than was the more proximal Assessment 2. This finding can most likely be explained by the modality of the assessments with Assessment 3 using the same or similar visual prompts as Assessment 1. Furthermore, during Assessment 2, children's responses were not constrained or limited by the set of pictures, but rather the children were free to talk about all of the conceptual connections they made about being healthy. Results also indicated that 3-year olds' Assessment 2 mean score was lower than that of the 4-year olds' and that Assessment 1 predicted Assessment 2 for both groups of children. This finding was expected as, on average, the 3-year olds' initial expressive vocabulary was between 3 and 4 words while the 4-year olds' initial expressive vocabulary was between 11 and 12 words. That this differentiation was maintained at Assessment 2 was expected; however, both groups showed the same level of improvement. The results of the analysis of final model of Assessment 3 predictors were unexpected. The difference in the predictive power of Assessment 2 relative to Assessment 3 can possibly be explained by the 3-year olds' initial lower expressive vocabulary scores; however, 3-year olds with high initial status had Assessment 3 scores similar to 4-year olds. When both preschool and prekindergarten children had low initial status, the 3-year olds outperformed the 4-year olds on Assessment 3. Finally, study findings should be cautiously considered because of low statistical power due to the small sample size and of the lack of generalizability due to the one childcare center context. However, the findings do suggest areas for further research.

Assessment 3 results tend to reinforce that providing a means for dual coding (Paivio, 2006), in this instance the class concept map with pictures and words and the reading of content related text, can enable young children "to read" the map and provide information about connections made during the instructional unit. Also, the finding that Assessment 1 score was predictive of Assessment 3 provides further evidence of the need to emphasize vocabulary and content learning in the early education years.

Through this implementation, the utility of concept maps to capture children's thinking was evident. In addition, the results provide insight into both training teachers to use concept maps and how to use the results to inform instruction.

7 Acknowledgement

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CONCEPT MAPPING PROFESSIONAL LEARNING: MAKING A DIFFERENCE IN PREKINDERGARTEN CLASSROOMS

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Abstract. The purpose of this paper is to report on the strategies used in a six-session professional learning series on the topic of concept mapping and the impact of the strategies on prekindergarten teachers' use of concept mapping in their classrooms. A group of 23 prekindergarten teachers participated in the six-session series, 17 of which completed the Stages of Concern Questionnaire (SoCQ) along with a survey to self-report their use of concept mapping. Respondents ranked six training activities based on their usefulness and reported how often they use concept mapping for instruction, planning, and assessment. Based on the findings of the SoCQ, fourteen of the respondents are non-users but according to the self-report all of the teachers use concept mapping at least once a month in their classrooms. Of the six training activities, the two involving printed pictures of concepts to include on a concept map were ranked the highest while the construction of a concept map during a training session was ranked the lowest.

1 Background: Why Are We Here?

A research institution housed at an American state university partnered with a local education agency (LEA) on an initiative to improve the transitions for students from prekindergarten through third grade. The overarching goal of the initiative was to develop a well-coordinated system to improve children's achievement with an emphasis on both horizontal and vertical alignment of curriculum (Florida Institute of Education, 2009). One activity that supports the goal was to design and implement a series of professional learning opportunities for teachers, the first of which involved prekindergarten teachers. To implement effective professional learning with teachers it is necessary to first identify a clear area where improvement is needed (Guskey, 2000). Thus before embarking, a team of university researchers conducted 60 classroom observations (18 prekindergarten and 42 kindergarten) using the Classroom Assessment Scoring System (CLASS: Pianta, La Paro, & Hamre, 2008). The CLASS is an observational tool specifically created to assess the quality of early childhood classrooms, and it consists of three measured domains: Emotional Support, Classroom Organization, and Instructional Support.

1.1 CLASS Results

CLASS results (FIE, 2009) indicated that, on average, prekindergarten teachers scored 6.1 out of 7 possible points for both Emotional Support and Classroom Organization domains, which are considered high quality. Conversely, the prekindergarten teachers, on average, scored 3.6 (out of 7) in the domain of Instructional Support. This is considered slightly below average in quality. Based on the CLASS results, we determined that Instructional Support would be the focus for professional learning opportunities for prekindergarten teachers.

1.2 Curriculum

A secondary finding was that the prekindergarten teachers did not use a curriculum, determined by the LEA, and in fact, teachers often used piecemeal curricula rather than a standards-based curriculum. Evident curriculum issues resulted in a lack of connection between the students' experiences in prekindergarten and their upcoming experiences in kindergarten. Relative to this finding, a new reading curriculum was adopted for use in prekindergarten. The selected reading series, Houghton Mifflin, is the K-3 reading curriculum. Simultaneous of the adoption of a new literacy curriculum, a new supervisor was assigned to the prekindergarten teachers.

2 Developing the Plan

Fullan, Cuttress, and Kilcher (2009) state that changes are not expected to go smoothly in the early stages of implementation and resistance is expected. In fact, Fullan et al. report that the change is much more complex when there are many individuals involved at the same time. Therefore, any plan for professional learning needed to take into consideration the number of changes that were impacting this group of teachers at one time.

The domain of Instructional Support is designed to emphasize how teachers promote students' higher-order thinking skills, extend students' learning, and facilitate and encourage students' language (Pianta, La Paro, & Hamre, 2008). Emphasis on Instructional Support requires consideration of its three dimensions: Concept Development (analysis and reasoning, creating, integration, connections to the real world), Quality of Feedback (scaffolding, feedback loops, prompting through processing, providing information, encouragement and affirmation), and Language Modeling (frequent conversations, open-ended questions, repetition and extension, self- and parallel talk, advanced language).

An instructional strategy that teachers can use to address the quality of the Instructional Support is concept mapping. Cassata-Widera (2008) used concept mapping as an instructional tool in an early childhood classroom and reported that it successfully facilitated the learning of several emergent literacy components. Goudy, Fountain, and Ossi (2008) also analyzed the use of concept mapping in prekindergarten classrooms with an emphasis on the connections children can make between concepts. Their results indicated that children benefited from the concept mapping experience.

3 Professional Learning Implementation

The prekindergarten teachers (all teachers of 4-year-old children) were involved in monthly professional learning workshops during the 2009-2010 school year. The workshops, each 90 minutes, were conducted during regularly scheduled professional learning sessions on early dismissal days for students. The content of each professional learning workshop focused on implementation of the newly adopted Houghton Mifflin curriculum with inclusion of instructional support strategies emphasizing concept mapping. Throughout the course of the professional learning series, six strategies were implemented with the prekindergarten teachers.

3.1 Strategy One: Creating Concept Maps with Post-it Notes

Novak's (2010) experiences with using concept mapping in lecture-type situations indicated the importance of the learner having experienced the construction of their own concept maps to better understand how the organizational structure presents the big picture of the content. With this in mind, the first two professional learning sessions were designed to provide participants the opportunity to create their own concept maps using chart paper and Post-it Notes. Participants were given a focus question at each workshop (i.e., What do we want children to learn about the five senses? and What do we know about the seasons?). The teachers worked in small groups and wrote down concepts to answer the questions on Post-it Notes. During the first session, participants were asked to use the current theme's curriculum guide to identify concepts, and during the second session participants were asked to use selections of children's literature to identify concepts. For each of these experiences, the participants were given a blank piece of chart paper and Post-it Notes to construct a concept map. They were not given a concept map structure to develop the map.

3.2 Strategy Two: Providing Computer-Generated Concept Maps

Following the completion of the initial strategy of concept map construction, teachers were given a computer-generated concept map (Figure 1) that had been designed by the researchers as a model of how concept maps can be used for planning purposes. These concept maps demonstrated how to organize and arrange the concepts in a hierarchical

fashion to form a concept map with the larger concepts at the top and the more detailed concepts at the bottom. The teachers were then asked to consider if their concept maps (with Post-it Notes) needed to be rearranged based on the provided model.

Computer-generated concept maps were distributed to teachers during five of the six professional learning sessions summarizing the content of their curricular themes. Additional computer-generated concept maps were also given in support of other strategies as described below.

3.2.1 Results of Strategy One and Two

The first two strategies were used during sessions one and two. During session two, teachers were asked to bring in an example of a concept map created in their classrooms. These first attempts at constructing concept maps resembled webs more than concept maps in that the maps did not represent a hierarchy nor did they include linking phrases. At this point teachers appeared to have incomplete knowledge of concept maps. Teachers understood the idea behind a concept map of connecting concepts but did not grasp the importance of the linking phrases and the flow from the top to the bottom. Because there seemed to be a missing link with the teachers, additional strategies were identified and implemented.

3.3 Strategy Three: Watching Video of Concept Mapping in a Prekindergarten Classroom

The third session began with a 7-minute video of a prekindergarten teacher creating a concept map with children. In the video, the teacher presented students with a focus question (What do you know about birthdays?), used pre-printed pictures to include in the concept map (i.e., birthday cake, candles, presents), asked guiding questions to lead the students in an anticipated direction (i.e., what do you see on the cake?), and included student-generated ideas on index cards if a pre-printed picture was not available. As the teachers watched the 7-minute video they observed a teacher creating a concept map with a group of 4-year-old children from start to finish. Following the video, the teachers were provided a copy of the computer-generated concept map created by the 4-year-olds in the video.

A second video clip experience occurred during session six. The video clips, which were used to demonstrate Language Modeling, were taken from a lesson on concept mapping. So, the Prekindergarten teachers observed a teacher engaging her students in frequent conversations, asking open-ended questions, modeling repetition and extension, practicing self- and parallel talk, and modeling advanced language while she was working on a concept map with her students. Additional emphasis was placed on concept mapping during the discussion on advanced language. Advanced language (Pianta, La Paro, & Hamre, 2008) is observed when a teacher uses a variety of words or makes connections to familiar words and/or ideas. A concept map is a strong tool for promoting advanced language because it is a graphic organizer that shows connections between concepts.

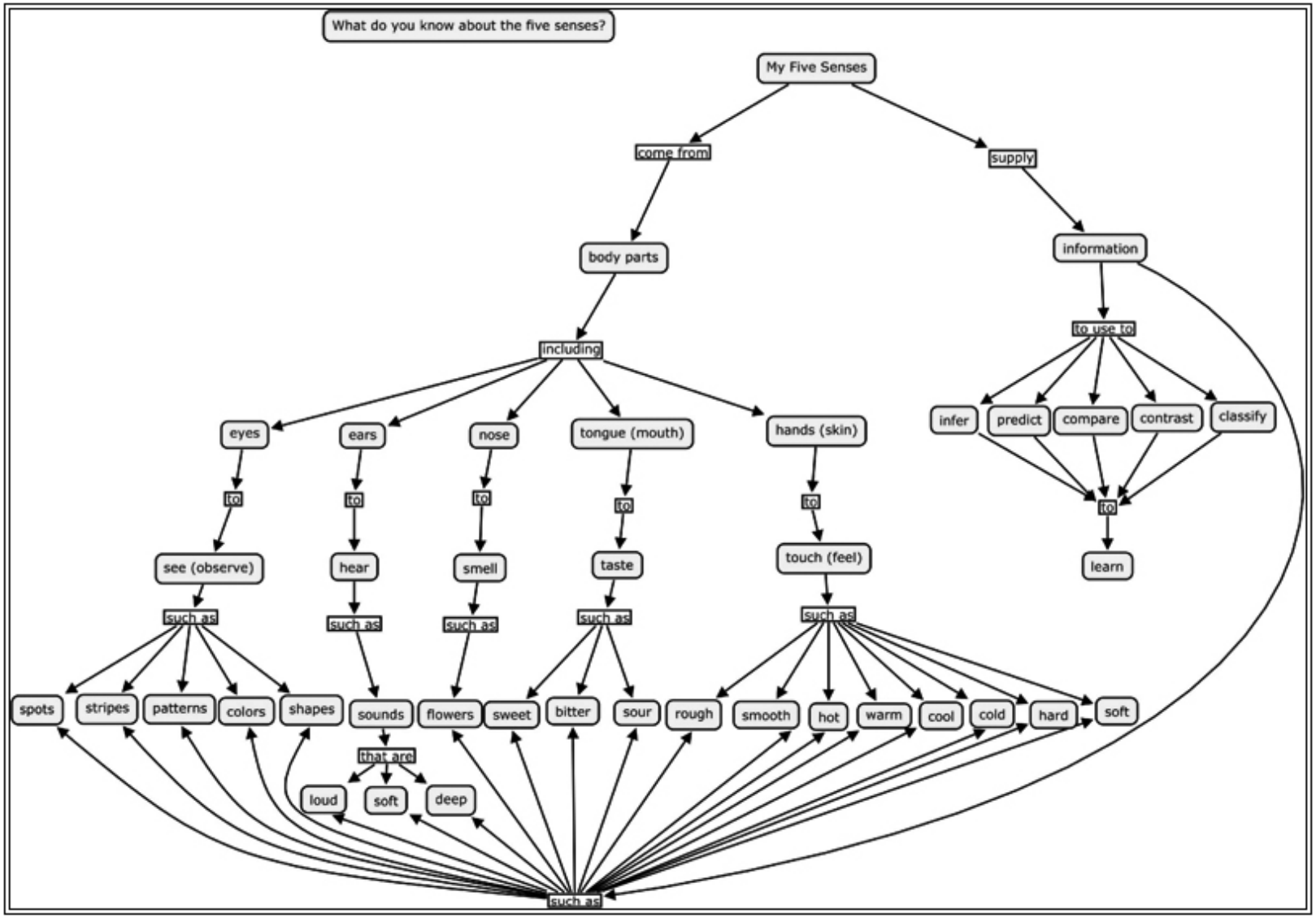


Figure 1. Computer-Generated Concept Map

3.4 Strategy Four: Turning Interactive and Shared Writing Activities into Concept Maps

Following the video activity in session three, concept mapping was applied to a lesson from the teachers' literacy curriculum. The activity suggested that teachers ask students which animals can be pets and then create a list of the students' responses using the format of 'A _____ can be a pet.' This activity could easily be a concept map instead of a list. Teachers were given an envelope containing 12 pictures and three linking phrases (Figure 2). They were also given a piece of chart paper with a concept map structure to be filled in with the provided pictures (concepts) and linking phrases.

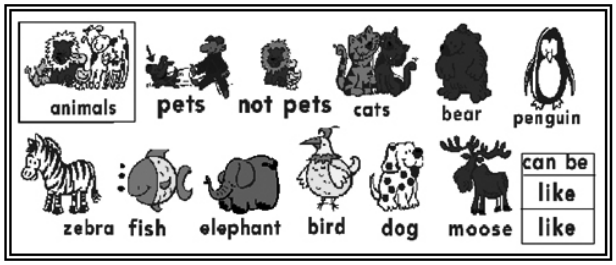


Figure 2. Picture and Linking Phrases

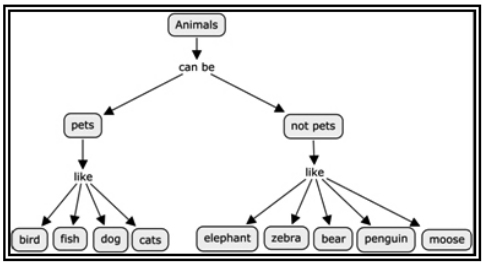


Figure 3. Animals Can Be Pets Concept Map

Teachers were asked to use the cutout pictures and linking phrases to fill in the concept map. The expected result is shown in Figure 3. These specific animals were selected for use in the map because the pictures were provided in the curriculum materials.

The teachers then looked at a different lesson in their curriculum guide. The lesson suggested that the teacher engage children in a more in-depth conversation about pets, add pets to the list from earlier in the day, and talk about who owned each pet. The lesson format was again changed to a concept mapping activity by adding more animals to the concept map created earlier and adding another level with the linking phrase 'owned by' as appropriate (i.e., Animals can be pets like (a) dog owned by Savannah).

Scaffolding was used for the third and final example of this strategy using another lesson from the curriculum. The lesson suggested that teachers engage students in a discussion to make a list of useful tools. In the training session, teachers were given a piece of paper and asked to sketch a possible concept map that could be developed with students instead of simply making a list. Teachers were given a piece of paper on which to construct a concept map but were not given a pre-determined structure as was done previously.

3.5 Strategy Five: Using Pictures in Concept Maps

Results of research conducted by Cassata-Widera (2008) indicated that photographs, used in addition to text with pre-readers, gave a visual tool for creating, manipulating, sharing, and interacting with language in a meaningful way. During each session on concept mapping, Prekindergarten teachers were encouraged to use pictures and words in the concept maps they create with students. After session two, the use of pictures in concept mapping was modeled for teacher in workshop activities, through videos, and provision of computer-generated concept maps. For example, teachers created their own concept maps, as suggested by Novak (2008), using pictures when they engaged in the activity (mentioned above) of animals that can be pets or not pets. Finally, the sample tools concept map, shown to the teachers after they created their own tools concept map, was created using pictures.

3.6 Strategy Six: Receiving Printed Pictures for Classroom Concept-Map Creation

Following the activities in which teachers created concept maps using pictures of animals and tools, they received a printed copy of the pictures. Teachers' reacted very positively to the pictures so during the final two professional

learning sessions, the teachers received a page of printed pictures matching the concepts on their curriculum's theme-based concept maps.

4 Results: What Did We Learn?

During the final professional learning session, the teachers were asked to complete a survey concerning the concept mapping professional learning. Seventeen of the 23 participating teachers provided feedback on their level of use of concept mapping in their classrooms, their reactions to the experiences in the professional learning session, and their suggestions for future professional learning planning.

4.1 Reported Level of Use

The teachers were asked how often they used concept mapping for instruction, planning, or assessment. Ten teachers reported using concept mapping for instruction at least once a week, 8 teachers reported using concept mapping for planning at least once a week, and 9 teachers reported that they never use concept mapping for assessment (Table 1).

Use	Two or more times a week	Once a week	Two or more times a month	Once a Month	Never
Instruction	5	5	3	4	0
Planning	2	6	4	3	2
Assessment	1	2	1	4	9

Table 1. Reported Level of Use (n=17)

4.2 Reaction to Training Activities

Teachers were asked to rank six training activities in order of usefulness (Table 2). On average, responding teachers ranked being given printed pictures to use for creating concept maps highest overall and being shown concept maps that used pictures and words as the second most useful activity. Ten of the 17 respondents listed one of these two picture-related activities as the specific activities in training that have encouraged them to use concept mapping. The activities that involved receiving computer-generated concept maps averaged as the third useful activity and received the greatest variation in rankings. Nine individuals ranked it in their bottom three while six individuals ranked it in their top three.

On average, responding teachers ranked watching a video as the fourth useful activity out of the 6 activities. The videos received the most last place votes (7 of 17) but also the most first place votes (5 of 17). The video of a teacher creating a concept map with children was shown in the third professional learning session. One teacher reported that she wished we had shown the video earlier because it helped her see how to implement concept mapping. In the same survey teachers ranked activities using concept mapping in interactive and shared writing activities as the fifth useful activity, but six individuals ranked it in the top three. One individual specifically listed the activities for making interactive and shared writing into concept maps as the activity that left her confused about concept mapping. The activity ranked as the least useful was creating concept maps with Post-it Notes. While the Post-it notes activities received low ranking, only one individual listed it as the specific activity in training that left them confused about concept mapping.

Rank	Training Activity
1st	Receiving printed pictures to match concepts in a book
2nd	Seeing examples of concept maps that are created with pictures
3rd	Receiving examples of computer-generated concept maps
4th	Watching video clips of a teacher using concept mapping
5th	Learning how to make interactive and shared writing activities from curriculum into concept mapping lessons
6th	Creating a concept map using Post-it notes and index cards

Table 2. Ranking of Training Activities

4.3 Stages of Concern

When individuals are introduced to a new innovation, it is expected that they will respond to the innovation in a variety of ways. The Stages of Concern Questionnaire (SoCQ: George, Hall, & Stiegelbauer, 2006) is an instrument that was developed to determine an individual's reaction to and use of a new innovation. The SoCQ is made up of 35 questions representing seven stages of concern (five questions per stage). Stage 0, Stage 1, and Stage 2 fall into the category of "Self" emphasizing, "How will this affect me?" Stage 0, Unconcerned, indicates an individual's lack of concern or use of the innovation. Stage 1, Informational, is the level of knowledge the individual has about the innovation. Stage 2, Personal, gives insight into the individual's concerns about what would be required of them in order to make the innovation work. The second category, "Task," is made up of only Stage 3, Management, and emphasizes an individual's concerns with the organization and management, or logistical issues related to the innovation and how much time it would require. The final category, "Impact," includes Stage 4, Stage 5, and Stage 6 and emphasizes, "How is this affecting those around me and is there a more effective strategy that could be used?" Stage 4, Consequence, indicates a shift in focus from self to students. Stage 5, Collaboration, reveals an emphasis on involvement with others concerning the innovation. Finally, Stage 6, Refocusing, brings to light an exploration of other possibilities other than the innovation or making changes to the innovation to bring about the same results.

4.3.1 Peak Stage Score Interpretation

Table 3. Peak Stage Scores

The first possibility for analyzing SoCQ results is to examine the highest stage score for each individual, which is called Peak Stage Score Interpretation. The 17 respondents fall into three categories based on their Peak Stage Scores (Table 3). Group one consists of 13 respondents who had peak scores in Stage 0, Unconcerned. High scores in Stage 0 do not indicate someone's level of use but there are other tasks taking priority for the individual. Four of the individuals in Group One had tying peak scores in Stage 3, Management. These individuals would appear to be making something else their priority while also expressing concern about time required to implement concept mapping. Group Two includes two individuals who had peak scores in Stage 1, Informational, which indicates that they would like to continue learning more about concept mapping. One of these individuals also had a high score in Stage 2, Personal, and Stage 5, Collaboration. Group Three consisted of two other individuals, one of whom peaked on Stage 2, Personal, and Stage 5, Collaboration. This individual seems to be concerned about how concept mapping will impact her directly along with the collaboration it will require. The final participant in Group Three had tying peak scores in three stages: Stage 2, Personal, Stage 3, Management, and Stage 6, Refocusing. These results indicate that the individual is concerned with how implementing concept mapping will impact her, how she will find time to manage the implementation of concept mapping, and whether or not there is a better way to accomplish the same results.

	Group One	Group Two	Group Three
Participants	**13**	**2**	**2**
Stage 0: Unconcerned			
Stage 1: Informational			
Stage 2: Personal			
Stage 3: Management			
Stage 4: Consequence			
Stage 5: Collaboration			
Stage 6: Refocusing			

Table 3. Peak Stage Scores

4.3.2 First and Second Highest Stage Score Interpretation

A second possibility for analysis is to examine both the highest and second highest stage scores. It is expected that the highest and second highest scores will be adjacent stages (George, Hall, & Stiegelbauer, 2006). This expectation proves true for 12 of the 17 respondents of this study (Table 4). Four of these 12 respondents scored highest in Stage 0 and second highest in Stage 1. These high scores indicate that these four individuals have other things to worry about and do not know enough about the innovation to use it. Another group of four out of these 12 respondents had highest scores in Stage 0 and Stage 3 and they all had a second highest score in Stage 2. These high scores indicate that these four individuals are concerned with how concept mapping will impact them (self) and their time (management). The other four individuals whose highest and second highest scores were in adjacent stages had high scores in Stage 1, Stage 2, or Stage 3. These individuals clearly have concerns with how the innovation will impact them and their time restraints.

Participant	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Stage 0: Unconcerned																	
Stage 1: Informational																	
Stage 2: Personal																	
Stage 3: Management																	
Stage 4: Consequence																	
Stage 5: Collaboration																	
Stage 6: Refocusing																	

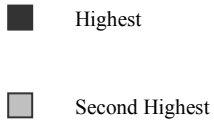


Table 4. First and Second Highest Stage Scores

The five respondents whose highest and second highest scores were not adjacent stages all had highest scores in Stage 0. Their second highest scores were in Stage 2 (one respondent), Stage 3 (three respondents), and Stage 6 (one respondent). The first four within this group still show concerns for how the innovation will impact themselves (Personal) and their time constraints (Management). The individual whose second highest stage was Stage 6 is suspect. A high score in Stage 0 indicates that the individual has other things to think about but a high score in Stage 6 indicates that the individual has ideas for how to change the innovation or use another strategy. Perhaps this individual is not concerned with concept mapping because she has an idea she thinks would be more effective.

4.3.3 Profile Interpretation

The third method for analyzing SoCQ results is a Profile Interpretation, which looks at the relationships and patterns among all seven stages of concern. As stated by George, Hall, & Stiegelbauer (2006) the nonuser profile is the most obvious to see. Nonusers tend to have higher scores on Stages 0, 1, and 2 and lower scores on Stages 4, 5, and 6. Of the 17 respondents in the present study on concept mapping, 14 would be described as nonusers. The other three participants do not easily fit into the "non-user" category because they had high scores in Stage 5 and Stage 6.

As described by George, Hall, & Stiegelbauer (2006), variations in the Stage 0 scores among nonusers are not as important as the variations between the scores in Stage 1 and Stage 2. If the Stage 1 and Stage 2 scores are very different, the individual results are explained as having a one-two split, which can be positive or negative. When Stage 1 is higher than Stage 2, it is a positive one-two split and the individual could be said to be a willing and interested party when it comes to the innovation. When the Stage 2 scores are higher than Stage 1 scores it is a negative one-two split and the individual will most likely have some level of doubt about the intervention and will likely be resistant to its implementation.

Based on the SoCQ results for the present study, five "non-users" have a one-two split. These five individuals more than likely have a positive, proactive perspective, with little concern for how the innovation will impact them personally. They would be referred to as willing and interested parties in the area of concept mapping but for some reason they are not yet using the tool. Four of the "non-users" have a negative one-two split indicating that they have some level of doubt about the intervention and will likely be resistant to its implementation.

4.3.4 Comparisons

According to the SoCQ results, 14 of the responding teachers could be considered "non-users" of concept mapping. However, on the self-reporting portion of the survey all of the teachers reported using concept mapping for instruction at least once a month and ten of the teachers reported using concept mapping at least once a week. There is a contradiction in these findings that will be interesting to pursue.

5 Implications: What Are the Next Steps?

It is expected that change will take time. The professional learning series analyzed through this study took place during one school year. The same participating teachers will continue with additional follow-up sessions covering the use of concept mapping in their prekindergarten classrooms. Based on the findings of this study, future concept mapping professional learning sessions with this group of teachers will need to focus on three strategies: the use of printed pictures in concept mapping, modeling the construction of a concept map based on lessons, and making connections between curricular lessons and the use of concept mapping.

Printed pictures were ranked as the most useful training strategy so continuing the use of printed pictures makes sense. The printed pictures are what helped the teachers see concept mapping as something they could do with their children but apparently not enough to make them use concept mapping on a regular basis. A strategy that needs to be strengthened in training sessions is the modeling of concept map construction. Quite a few of the teachers repor-

ted being confused about what they were supposed to do with concept mapping so infusing more modeling into the sessions will help. When the modeling is implemented it will need to be done with the prekindergarten teachers' literacy curriculum lessons in mind. It seems as though the current participating teachers saw concept mapping as an activity that they learned about in professional learning sessions but did not make the transition for implementing it into their lessons. Hopefully by seeing concept mapping activities using curricular lessons and printed pictures in training sessions the teacher will begin to make the shift towards accepting and implementing concept mapping into their classrooms.

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Viña del Mar, Chile, 2010

CREATING DIGITAL HERBARIUM IN PRIMARY SCHOOL USING OWN PHOTOS, NATUREGATE ONLINE SERVICE AND CMAPTOOLS

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Abstract. A school project of creating digital herbarium in primary school using own photos, CmapTools and NatureGate Online Service is described and analyzed as a case study. Ten year old pupils used six concepts to group the species they found. The dominant concept in pupils thinking was 'flowering plants'. The pupils used this concept in much narrower sense than what is biologically flowering plants (Angiospermae). They used a large concept of "other plants", that included six biologically flowering plants and one fern. They did not include berries to flowering plants, neither dwarf shrubs or trees and bushes. Pupils were developing their own everyday theory of plants that later on will be contrasted with that of biological systematics. The teacher had made a decision that first pupils can express their own theory. Later on they can learn how the same species can be easily grouped in more scientific way. Pupils expressed that they liked taking photos of plants, using CmapTools and NatureGate Online Service. This first pilot of making digital herbaria can be used at least in Finland where the national core curriculum support this kind of activity. Global decline of biodiversity ought to be stopped. Accordingly, everywhere creation of local digital herbaria would probably promote conservation and sustainable use of biodiversity.

1 Introduction

Concept mapping can be used in many ways in education, in classroom practice, development and in research for organizing and integrating concepts and thinking. Novak (1990, 29) defines concepts as perceived regularities. Plants species and their unexpected mutations are not always perceived regularities, although mostly they are. In this paper concepts are defined as main elements of thinking and learning (Åhlberg 1993 and 2004a). Predecessors of modern concept mapping in 1970's links were lines without linking phrases (Novak 1979 and 1980; Novak & Gowin 1984, 182). These first concept maps were like ordered association maps. In education there is still contexts in which this kind of approach is practical, although usually the most advanced concept maps include linking phrases and arrows to show reading direction. When linking phrases between concepts are used, full propositions are formed between two concepts. The concept map and the text it represents become more accurate, meaningful and deep. One of the rare circumstances when ordered associations are useful is creation of classroom digital herbarium using CmapTools and NatureGate (Fig. 1.)

Biodiversity is declining. United Nations has nominated the year 2010 as International Year of Biodiversity. (http://www.cbd.int/2010/about/) NatureGate Online Service to promote species identification and sustainable use of biodiversity was founded in 2006. From the very planning of NatureGate Online Service, concept maps and CmapTools were planned to be used for collaborative knowledge building, e.g. creation of digital herbaria (Åhlberg, Lehmuskallio & Lehmuskallio 2006a – 2006c). The point is that children learn to identify far too little plants and other organisms. Because of exotic TV documentaries, children and adults may know more about animals and plants of tropical countries than about their own local environment.

According to the Finnish School Curriculum Guidelines for classes 1 - 6 (Curriculum 2004), pupils ought to study and learn to identify local species and ecosystems. The suggested "methods" include inquiry-based learning and experiential learning. Paukkunen (2010) has planned a learning environment for a shared classroom digital herbarium. His theoretical framework is in the Figure 1. He taught pupils to use CmapTools software. Pupils themselves created a shared digital herbarium. This in an empirical research, what happened and what can be learnt from this case study for future.

The following research problems came out of earlier theoretical and empirical work (Paukkunen 2010, Åhlberg 1993 – 2008c, Åhlberg & al. 2006a – 2009, Lehmuskallio, Lehmuskallio, Kaasinen & Åhlberg 2008):

(1) What are the core concepts of pupils' thinking about local plants, when they created a digital herbarium?

What else can be learnt from pupils' use of concept map in their digital herbarium project?

(2) What is common and what is different and what is similar between thinking of an expert in biology and the 4th graders creating a digital herbarium?

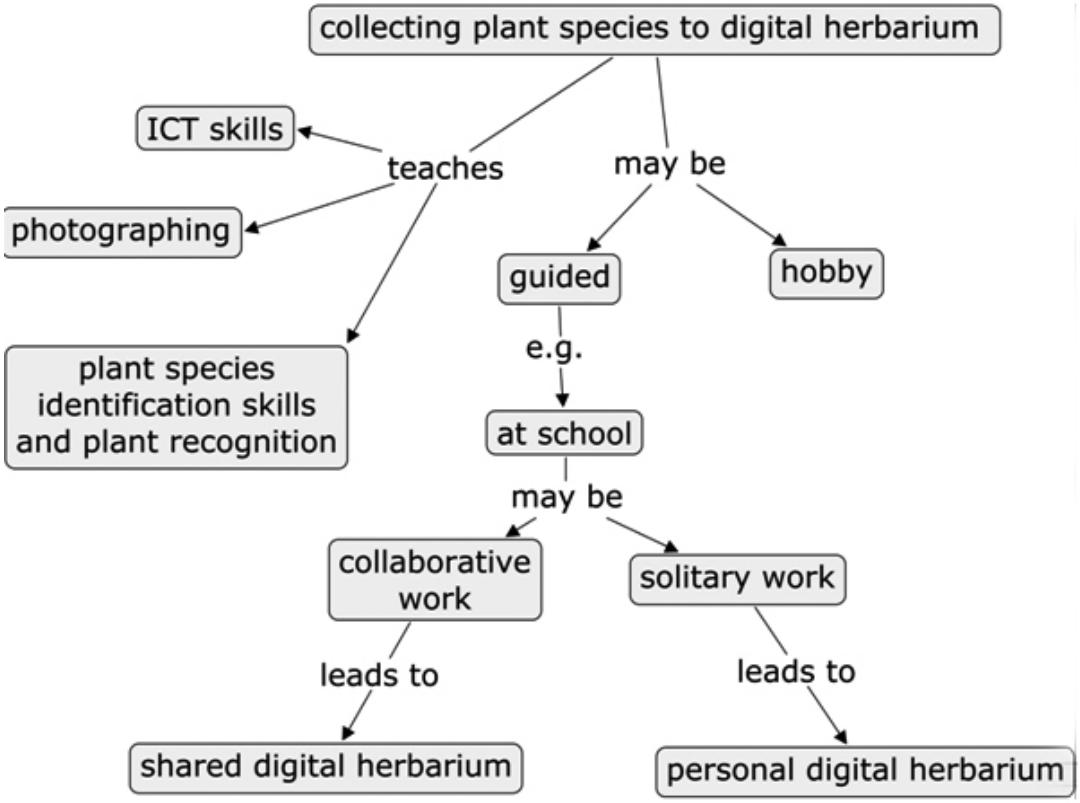


Figure 1. Theoretical framework of Paukkunen's Master's Thesis as a background for the paper.

2 Method

One of the aims of this paper is to develop methods to aid teachers and pupils during digital herbarium construction.

2.1 Subjects

Pupils who created the digital herbarium were 4th graders, about 10 years old. There were eleven girls and eleven boys. All took part in construction of the digital herbarium. Both the teacher and pupils were excited with this task of identifying species and creating a digital herbarium using CmapTools. All of them told that they loved use of both CmapTools and NatureGate Online Service.

2.2 Data

The first plants were photographed September 5, 2009. Most of the photos were taken in Fall 2009. Together pupils took 311 digital photos of local plants. Some of the photos were not technically good enough. The same plants were photographed many times. The class identified 130 photos of species. Only a part of these photos were selected to be used in the digital herbarium of the class. The project ended in May 2010, but there may become minor changes also after that.

Pupils created a concept map as a platform for their digital herbarium (Figure. 2).

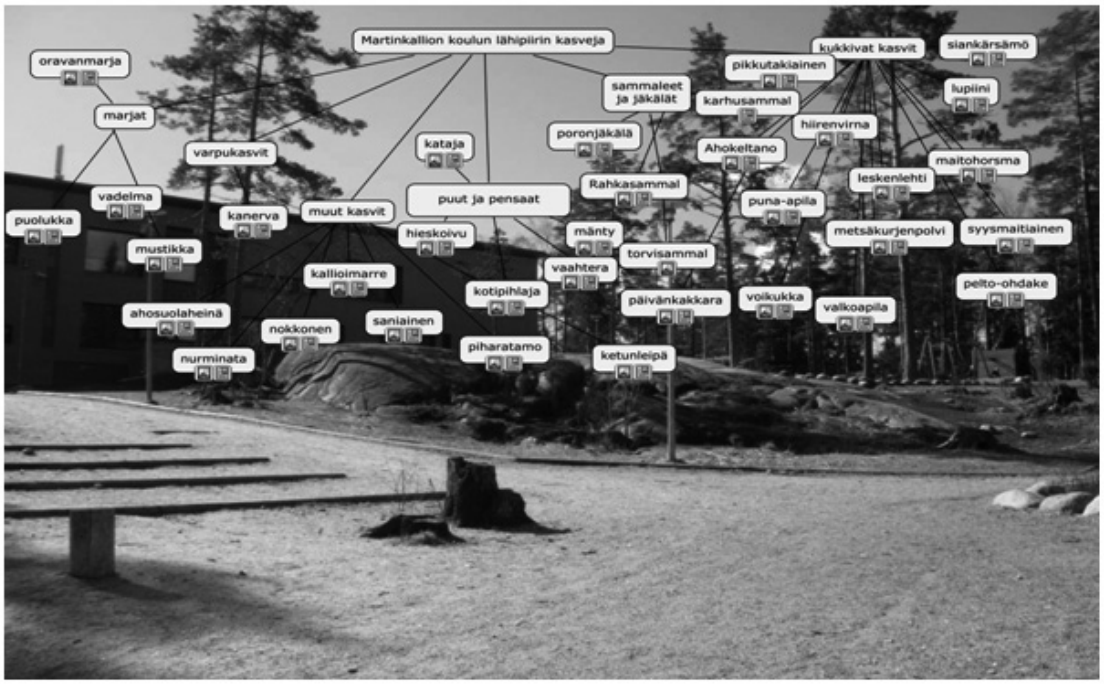


Figure 2. Original Finnish concept map created by ten year old primary school pupils as a part of their learning task of inquiring on wild plants in their school neighborhood.

2.3 Data analysis

Because of the dark colors of the background photo of the concept map in Figure 1, lines linking concepts are not clearly seen. The background photo is removed in the English translation of this concept map (Figure. 2).

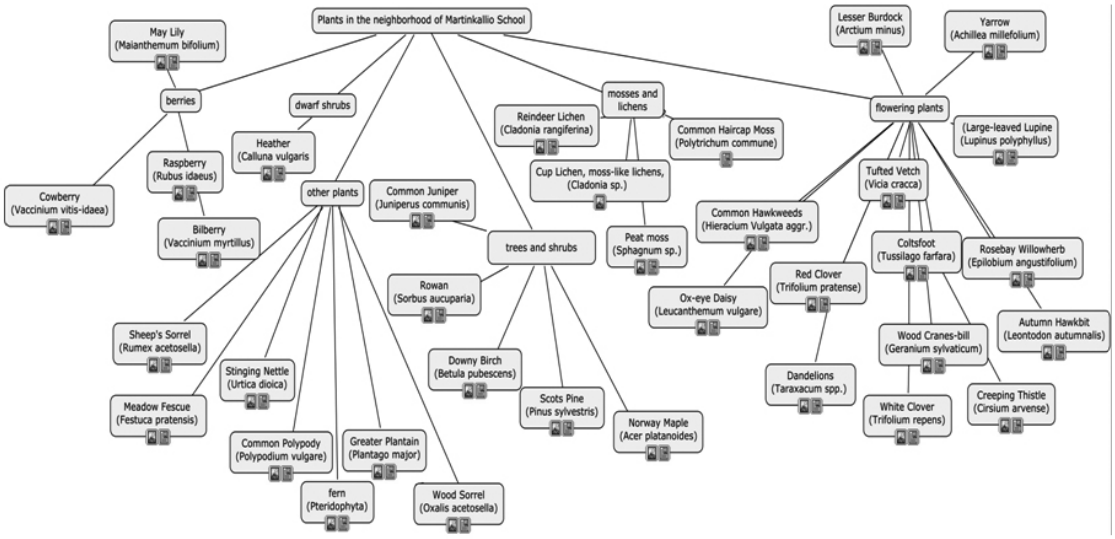


Figure 3. English translation of the skeleton concept map. To increase international accuracy scientific Latin names of species and species groups are added in parentheses.

The translated map with original functional links attached to concepts can be studied in the following web address: http://cmap.helsinki.fi:8001/rid=1H9W6F1PG-2CGC9H1-6T7/4a_English.cmap

2. 4. Validity and reliability

Case studies have special ways how to evaluate their validity and reliability. Because pupils were ordinary Finnish school pupils, who followed with their teacher the Finnish National Core Curriculum, the results of this study can be generalized conceptually/theoretically to other similar situations/contexts. Of course there are no possibilities of generalization in statistical sense. According to Åhlberg & Ahoranta (2008, 2) theoretical generalization is possible, because the researched pupils and their teacher are cases of real pupils and real teachers respectively (Cook, Leviton & Shadish 1985, 763 – 764; Yin 1998; de Vaus 2002, 148). Purposeful samples of real pupils allow us to conclude that under the similar conditions, similar phenomena are likely to happen.

3 Results

Answer to the first research question: What are the core concepts of pupils' thinking about local plants, when they created a digital herbarium? What else can be learnt from pupils' use of concept map in their digital herbarium project?

Åhlberg (1993 – 2008a) has suggested that centrality of each concept can be calculated from the number of links to and from each concept. Following this rule the core concepts of the digital herbarium map are: (1) 'flowering plants' with 15 links to other concepts, (2) 'other plants' with eight links to other concepts, (3) 'trees and shrubs' with six links to other concepts, (4) 'berries' and 'mosses and lichens' with the same number of five links to other concepts. The concept of 'dwarf shrubs' is clearly at the same level than other five core concepts, although it has only two links to other concepts. Together pupils have used six upper than species level concepts. Åhlberg's (1993 – 2008a) definition of concept implies that concept is a set in mind. In the concept maps created by pupils, there are six sets of species level concepts. 'Flowering plants' has 14 species as elements, 'dwarf shrubs' has only one species as an element in the set.

It is also noteworthy, that only a small part of pupils, three of twenty-two, thought that it was important to create groups or core concepts of digital herbaria and thus grouping plants correctly. All of them were academically very good pupils. Results indicate, that for the most of the pupils, only one core concept or category, such as "plants in the neighborhood of Martinkallio school", would have been enough. In the mind of an average 4th grader of Martinkallio school, there seems to be no certain need to even group or categorize plants. This may in part explain various shortcomings in grouping or creating of core concepts. Plant species identification, on the other hand, was considered as very important task, through the whole class.

Answer to the second research question: What is common and what is different and what is similar between thinking of an expert in biology and the 4th graders creating a digital herbarium?

An expert of biodiversity research compared his view to pupils' categories and came to the following conclusions:

(a) The plant species presented belong biologically into four main groups:

(I) flowering plants (Angiospermae) that covers pupils' narrower concept of "flowering plants", "berries", "trees and shrubs", "dwarf shrubs" and "other plants" excluding "ferns" that belong to the bigger group of Ferns (Pteridophyta) at the same level that flowering plants (Angiospermae).

(II) Ferns (Pteridophyta) and

(III) mosses (Bryophyta)

(IV) lichens are a complex group biologically because they have both a fungus partner and an algae partner living closely symbiotically together.

The pupils' concept of "other plants" is especially interesting because it includes six flowering plants and one fern. One of the six flowering plants is a grass species, the only member of monocots (Monocotyledonae). All other flowering plants belong to dicots (Dicotyledoneae).

4 Discussion

Differences between thinking of an expert in biology and 4th graders were quite significant. 4th graders did not know how to present plants in biologically correct groups. They used categories that do not exist in academic biology or they allocate plants into groups they don´t belong. This gives teacher important information about pupils´ skills, or lack of it, in plant classification. This information can be effectively used, as an indication of a level of pupils´ current knowledge, in planning future teaching or school projects.

We have found no other studies of digital herbaria created by pupils. This is partly because in very few countries learning to identify and recognize species is so prominent than in Finland. However, because biodiversity is declining this kind of activity could be used everywhere. This paper is based on Paukkunen's (2010) becoming Master's Thesis supervised by Professor Mauri Åhlberg. The results of this case study have been very inspiring to other classroom teachers from the same school and even from other schools who have heard the preliminary results. Conceptually/ theoretically results can be easily generalized to other similar situations. CmapTools and primitive concept maps were excellent organizing tools for digital herbarium. NatureGate Online Service is functional in Finland, and it was used because of its high quality.

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Concept Maps: Making Learning Meaningful
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DETERMINACIÓN EXPERIMENTAL DEL INCREMENTO DE APRENDIZAJE OBTENIDO MEDIANTE LA UTILIZACIÓN DE MAPAS CONCEPTUALES Y CMAPTOOLS. COMPARACIÓN DE LA CANTIDAD DE APRENDIZAJE SOBRE LAS FIBRAS ÓPTICAS CONSEGUIDO UTILIZANDO MAPAS CONCEPTUALES Y SIN UTILIZARLOS

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Abstract. La pregunta de enfoque que ha guiado el trabajo de investigación que se presenta en esta comunicación ha sido la siguiente: ¿Cuánto incremento de aprendizaje de un determinado tema de estudio se consigue debido al hecho de utilizar mapas conceptuales y CmapTools para estudiarlo? El estudio se ha llevado a cabo con 114 alumnos universitarios de diferentes titulaciones de la Universidad de Extremadura (España). Se ha dividido al conjunto de alumnos en dos grupos, uno experimental, que ha utilizado como estrategia de aprendizaje mapas conceptuales realizados con CmapTools, y otro de control que ha estudiado el mismo tema, pero utilizando solamente textos, sin mapas conceptuales. El análisis estadístico comparativo de los datos obtenidos con ambos grupos nos permite afirmar, por ejemplo, que debido a la utilización de los mapas conceptuales y CmapTool, hay un 95% de probabilidad de que el promedio del incremento de aprendizaje de los diferentes ítems sea superior a un 19%.

1 Introducción

Los componentes del Grupo Orión de Investigación llevamos más de veinte años enseñando a nuestros alumnos (muchos de ellos profesores a su vez) a trabajar con los Mapas Conceptuales para ayudar a alcanzar un aprendizaje significativo. (Novak & Gowin,1984; Pérez, Peña & Mahedero, 1979; Pérez, Suero, Montanero & Pardo, 2001; Pérez, Suero, Pardo &Montanero, 2006; Jonassen, 2000). Aunque está ampliamente aceptado que con la utilización de los mapas conceptuales nuestros alumnos aprenden más, (Novak, 1998; Pérez, Suero, Pardo & Montanero, 2006) una pregunta que se nos plantea con mucha frecuencia es la de: "Pero…, ¿cuánto más que si no los utilizaran?". Entendemos que esta pregunta surge para evaluar si merece la pena el esfuerzo de aprender a usar los mapas conceptuales, en función de la cantidad extra de aprendizaje que se puede obtener cuando se utilizan en el estudio de una materia. Partiendo del convencimiento de la mayoría de los profesores y alumnos que utilizan los mapas conceptuales y el programa CmapTools (Cañas et al., 2004; Pérez, Suero, Montanero & Pardo, 2004) de que constituyen unas potentes herramientas de trabajo que aumentan considerablemente el aprendizaje de los alumnos, con el estudio que aquí se presenta se ha pretendido cuantificar con datos experimentales este convencimiento subjetivo.

Esta investigación se ha llevado a cabo con alumnos de la Universidad de Extremadura de diversas titulaciones durante los cursos escolares 2008-09 y 2009-10. La experiencia ha consistido en un estudio comparativo entre los resultados obtenidos por dos grupos de alumnos, uno experimental y otro de control, que estudiaron utilizando una metodología didáctica diferente cada uno. La del grupo experimental basada en el uso de mapas conceptuales y la del grupo de control basada en una enseñanza tradicional sin utilizar mapas conceptuales. Las conclusiones obtenidas en este trabajo nos han permitido dar respuesta a nuestro planteamiento inicial, "SÍ, con la utilización de los Mapas Conceptuales nuestros alumnos aprenden más, pero ¿cuánto más?" Con el análisis estadístico de los datos recogidos en este estudio, podemos afirmar, por ejemplo, con un margen de error inferior al 5%, que la aplicación de una metodología didáctica basada en el uso de mapas conceptuales y CmapTools, produce un incremento comprendido entre el 18,89% y el 24,65% en la cantidad de aprendizaje promedio en un determinado ítem de un grupo de alumnos.

2 Objetivos

El objetivo principal de esta investigación ha sido determinar experimentalmente el incremento de aprendizaje que se obtiene al utilizar mapas conceptuales y CmapTools, mediante un análisis comparativo entre los resultados obtenidos por un grupo de alumnos de control y un grupo de alumnos experimental. El estudio estadístico para estimar el incremento de aprendizaje puede llevarse a cabo en relación a la materia de aprendizaje o en relación a los alumnos. Esto a su vez puede hacerse en relación a un ítem individual o a un test completo, y en relación a un alumno individual o a un grupo de alumnos. Además, el incremento de aprendizaje puede ser cuantificado dentro de un cierto rango o determinar si es mayor a un nivel concreto. Teniendo todo esto en cuenta, surgieron ocho preguntas de investigación

que desglosaron el objetivo general en los ocho objetivos específicos que aparecen en el mapa conceptual de la Figura 1. El trabajo realizado para encontrar la respuesta a los cuatro primeros objetivos específicos constituye el contenido de esta comunicación, habiéndose dejado los cuatro últimos objetivos específicos para otra comunicación presentada a este mismo congreso, que lleva por título "Determinación experimental del incremento de aprendizaje obtenido mediante la utilización de mapas conceptuales y CmapTools. Comparación de la cantidad de aprendizaje obtenido por los alumnos utilizando mapas conceptuales y sin utilizarlos".

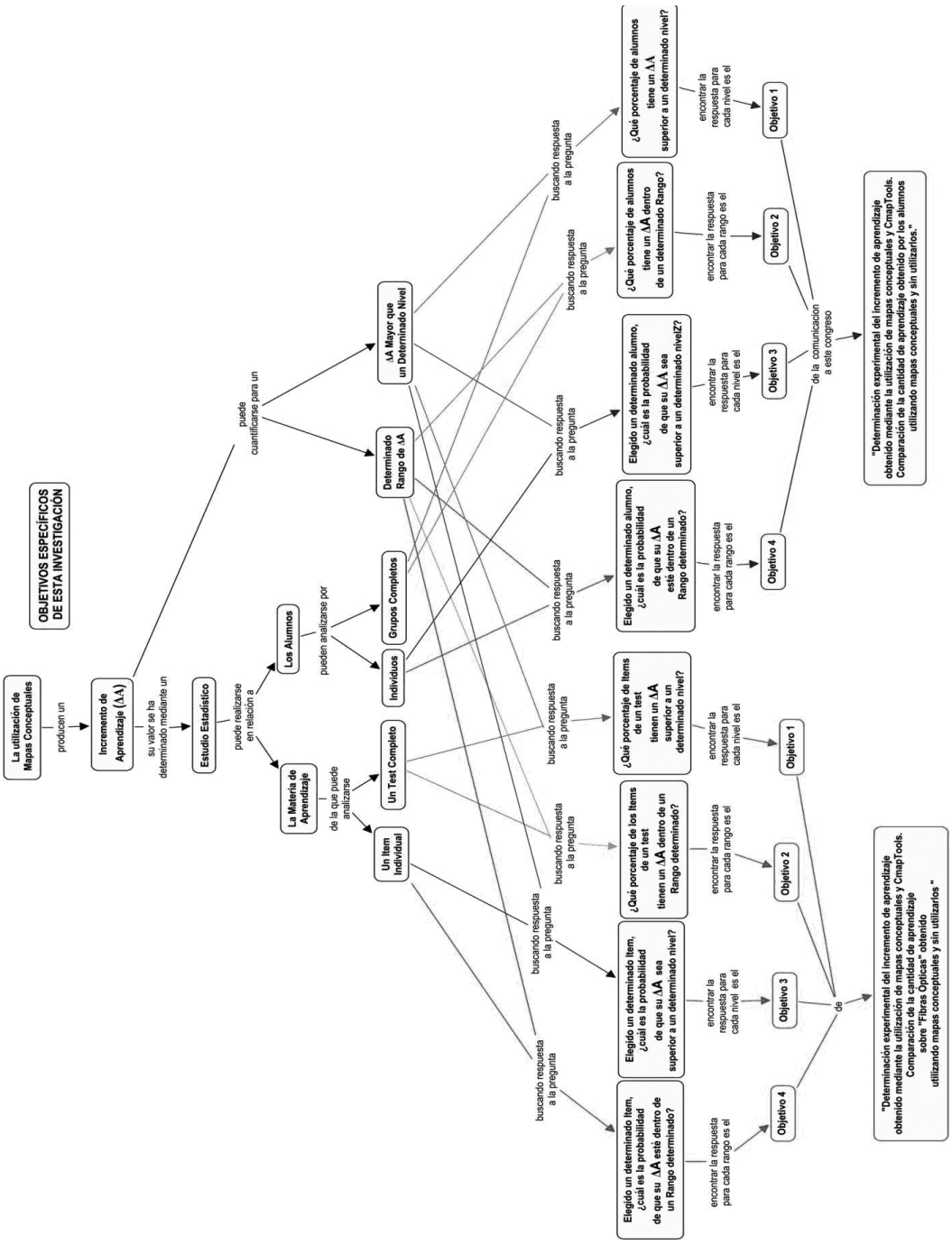


Figura 1. Mapa conceptual sobre los objetivos específicos de esta investigación

3 Métodos

3.1 Diseño de la Investigación

La investigación se ha desarrollado siguiendo un diseño cuasi-experimental con post-test y grupo de control. Las hipótesis iniciales planteadas al comienzo de este trabajo fueron:

- Hipótesis Nula (H0): "No existe un incremento en el aprendizaje promedio conseguido por un grupo de estudiantes que trabaje con mapas conceptuales, frente a un grupo equivalente de alumnos que no utilice mapas conceptuales para el estudio de una misma materia".
- Hipótesis Alternativa (H1): "Existe un incremento en el aprendizaje promedio conseguido por un grupo de estudiantes que trabaje con mapas conceptuales, frente a un grupo equivalente de alumnos que no utilice mapas conceptuales para el estudio de una misma materia".

En la investigación se ha considerado como variable independiente la metodología didáctica (usar mapas conceptuales y CmapTools o no utilizarlos). Para garantizar la validez de nuestro estudio se ha intentado controlar las posibles variables interferentes. Un análisis de las mismas nos llevó a concluir que las que más influencia podrían tener serían: las características del conjunto de alumnos seleccionado, la elección del grupo de control y experimental, el tema de estudio elegido y la capacidad didáctica del profesor.

3.1.1 Población

Las características de los alumnos elegidos para llevar a cabo la experiencia pueden interferir en los resultados, por ejemplo, hay que tener en cuenta factores como la capacidad de concentración o la disciplina. Por esta razón se eligió a alumnos de nivel universitario. Estos alumnos constituyen un grupo más homogéneo que los de enseñanzas medias, cuentan con un grado de concentración mayor, mejor capacidad para asimilar contenidos, son más disciplinados y están más acostumbrados a la realización de pruebas escritas. En concreto, la investigación se ha llevado a cabo durante los cursos académicos 2008-09 y 2009-10, con 114 alumnos de los últimos cursos de la Facultad de Ciencias, de la Escuela de Ingenierías Industriales y de diversos Másteres de postgrado.

Los 114 alumnos se han dividido en dos grupos de trabajo, homogéneos y equivalentes en cuanto a capacidades, titulación y al rendimiento académico mostrado en cursos anteriores.

- El primer grupo se ha denominado "Grupo de Control" (G.C.) y ha estado constituido por 57 alumnos. Este grupo ha estudiado la materia de aprendizaje utilizando un conjunto de textos bibliográficos proporcionados por el profesor, sin la ayuda de mapas conceptuales.
- El segundo grupo se ha denominado "Grupo Experimental" (G.E.) y ha estado formado por 57 alumnos de las mismas titulaciones que los pertenecientes al grupo de control. Este grupo experimental ha estudiado la misma materia que el G.C. utilizando un conjunto de 13 mapas conceptuales, realizados con la herramienta informática CmapTools, enlazados entre sí, formando un modelo de conocimiento avanzado sobre la materia objeto de estudio. Estos mapas conceptuales han sido realizados por los profesores de nuestro grupo de investigación Orión. Para la realización de los mismos, los profesores han utilizado los textos bibliográficos facilitados a los alumnos del G.C. para que los contenidos conceptuales de ambos grupos fuesen comunes.

3.1.2 Elección del tema de estudio

El tema de estudio elegido es una posible variable interferente en la realización de la investigación, es decir, los resultados podrían ser diferentes en función de la materia estudiada. Por ejemplo, la existencia de más o menos conocimientos previos de la materia estudiada influye en el nivel final alcanzado por un determinado alumno. Para homogeneizar lo máximo posible el punto de partida de los alumnos respecto al tema a estudiar, y delimitar mejor la diferencia real en la cantidad de aprendizaje obtenido por ambos grupos, se optó por elegir una materia con contenidos de un nivel elevado. Es decir, que no hubiese sido estudiado con anterioridad en ninguna de las asignaturas de las titulaciones de los alumnos que componían el grupo de control y el grupo experimental. Esta elección nos permitió eliminar la influencia que presenta la variable "Conocimientos iniciales" de los alumnos, no siendo necesario realizar un test de conocimientos previos. Por estos motivos, el tema por el que se ha optado fue el de "Estudio avanzado sobre Fibras Ópticas".

3.1.3 Metodología Didáctica Aplicada por el Profesor

La cantidad de aprendizaje que pueden alcanzar los alumnos en el estudio de una materia puede variar en función de la capacidad didáctica del profesor que realice las explicaciones. Para minimizar la influencia de esta posible variable interferente se decidió que un mismo profesor trabajase con ambos grupos, para poder comparar la cantidad de aprendizaje obtenido por los alumnos utilizando mapas conceptuales y CmapTools y sin utilizarlos. De este modo, los alumnos del G.C. han estudiado sólo con la ayuda de los textos bibliográficos suministrados por el profesor y los alumnos del G.E. han estudiado con la ayuda de los mapas conceptuales estructurados y realizados por el profesor con el programa CmapTools. Para minimizar la influencia del tiempo de dedicación de cada grupo se fijó un tiempo de estudio igual para ambos.

3.2 Modelo de conocimiento utilizado

Los mapas conceptuales realizados sobre fibras ópticas utilizados en esta investigación se han enlazado entre sí formando un modelo de conocimiento utilizando el programa CmapTools. (Cañas et al., 2000; Novak & Cañas, 2007). Estos trece mapas se encuentran alojados en nuestro sitio Cmap "Universidad de Extremadura (España)" dentro de la carpeta "Comunicaciones a Congresos" http://grupoorion.unex.es:8001/servlet/SBReadResourceServlet?viewhtml donde pueden ser utilizados de manera interactiva mediante la aplicación informática CmapTools. La Figura 2 muestra el epítome general de la secuencia de mapas desarrollados.

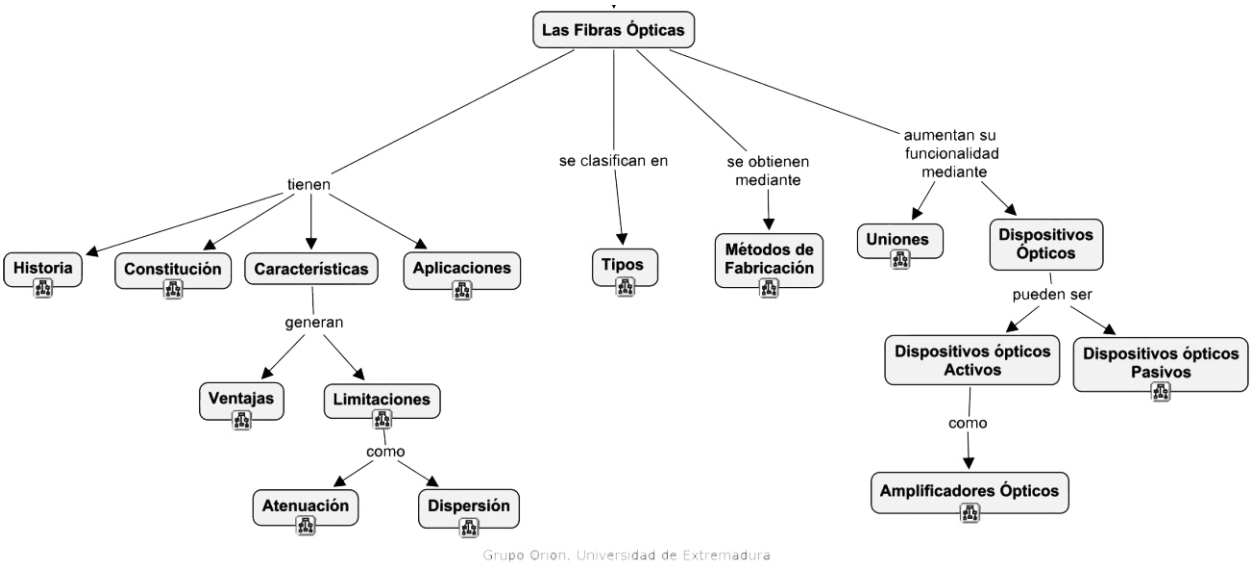


Figura 2. Epítome General del modelo de conocimiento elaborado sobre fibras ópticas

3.3 Instrumentos de evaluación aplicados

Para cuantificar el aprendizaje de tipo conceptual alcanzado se optó por la realización de una prueba escrita diseñándose un test como instrumento de evaluación. Inicialmente se elaboraron 120 ítems que fueron pasados a un grupo piloto de veinte alumnos que no iba a ser objeto del experimento, y se aplicó el programa informático LXR-TEST para eliminar las posibles preguntas que no tuvieran un índice de discriminación suficiente. Este análisis de los ítems se hizo a dos niveles, un nivel cualitativo para verificar la concordancia del contenido que se quiere evaluar con la formulación de los ítems, y un nivel cuantitativo para calcular el índice de discriminación de cada uno de ellos. Tras este análisis, se reconstruyó un test final de tipo dicotómico compuesto de 100 ítems (que también se encuentra disponible en nuestro sitio Cmap) que fue el que se pasó como post-test a cada grupo una vez finalizado el estudio del tema.

3.4 Análisis estadístico

Con el fin de contrastar las hipótesis planteadas al inicio de esta investigación, se ha realizado un análisis estadístico-descriptivo de los resultados obtenidos en los test de evaluación, buscando las medidas de tendencia central y de variabilidad mediante la prueba de normalidad de la distribución de puntuaciones. Este análisis nos ha permitido valorar los incrementos de aprendizaje obtenidos por los alumnos de cada grupo.

4 Resultados y Discusión

Los datos obtenidos en los test de evaluación han sido analizados con el paquete estadístico PASW Statistics 18.
Los test de evaluación que se han utilizado en esta investigación han sido iguales para los dos grupos de alumnos. Se muestra a continuación los resultados de las medias obtenidas en los 100 ítems para los alumnos de cada grupo de trabajo y la diferencia de puntuación entre ambos grupos. La Tabla 1 incluye el tamaño muestral, la media, la desviación típica, el error estándar de la media y los percentiles.

		Grupo Experimental	Grupo Control	△ Aprendizaje
N	**Items**	100	100	100
Media		**83,51**	**61,74**	**21,77**
Desviación típica		**7,94**	**12,25**	**10,45**
Percentil	25	78,94	54,39	14,03
	50	82,46	63,16	21,05
	75	89,47	70,17	29,82

Tabla 1. Análisis estadístico descriptivo de las respuestas del G.C. y del G.E.

Podemos apreciar que existe una diferencia entre las medias obtenida por el grupo de alumnos del G.E. y los alumnos del G.C. en el test de conocimientos conceptuales realizado. Para conocer si esta diferencia entre los grupos es significativa, se formula una hipótesis nula que plantea: "No existe un incremento en el aprendizaje promedio conseguido por un grupo de estudiantes que trabaje con mapas conceptuales, frente a un grupo equivalente de alumnos que no utilice mapas conceptuales para el estudio de una misma materia". Para aceptar o rechazar esta hipótesis, se ha realizado una prueba de Levene de igualdad de varianzas y una prueba t para la igualdad de medias cuyos resultados se muestran en la Tabla 2.

Incremento de Aprendizaje (△A)			Se han asumido varianzas iguales en ambos grupos	No se han asumido varianzas iguales en ambos grupos
Prueba de Levene para la igualdad de varianzas	F		15,24	
	Sig. (significación)		0,00	
Prueba t para la igualdad de medias ($\alpha = 0.05$)	t		14,91	14,91
	g.l. (grados de libertad)		198	169,77
	Sig. (Significación bilateral)		0,00	0,00
	Diferencia de medias		**21,77**	**21,77**
	Error típico de la diferencia		**1,45**	**1,45**
	95% Intervalo de confianza	Inferior	18,89	18,89
		Superior	24,65	24,65

Tabla 2. Prueba t para muestras independientes para un p-valor $p < 0.05$

La diferencia de medias encontrada ha sido de 21.77 con un error típico de la diferencia de 1.45. Para analizar si esa diferencia es significativa como para poder rechazar o no la hipótesis nula nos fijamos en el valor t obtenido (t = 14.91). Para saber si este valor de t es lo suficientemente grande para rechazar la hipótesis nula a un nivel de significación de 0.05 calculamos la significación bilateral. El valor obtenido para la misma es 0.00, lo que nos permite afirmar que la probabilidad estimada de que la hipótesis nula sea verdadera es menor que el 5% ($p<0.05$). Esto nos permite rechazar la hipótesis nula (Ho) y aceptar la hipótesis alternativa planteada (H1). Los datos son lo suficientemente significativos para llegar a la conclusión de que la diferencia encontrada entre ambos grupos no depende sólo del azar. Esto nos permite afirmar con un intervalo de confianza del 95% que el incremento de aprendizaje medio obtenido en cada ítem por los alumnos que usan los mapas conceptuales para el estudio de las fibras ópticas está entre el 18,89% y el 24,65%.

En la Figura 3, se representa gráficamente el histograma y la curva gaussiana de distribución normal de la distribución de frecuencias para la variable "Incremento de Aprendizaje" (ΔA). Como se aprecia en la figura, la campana de Gauss obtenida es prácticamente simétrica respecto al eje vertical que pasa por el valor de la media obtenida, correspondiente a un incremento de aprendizaje del 21,77% y una desviación típica de 10,4.

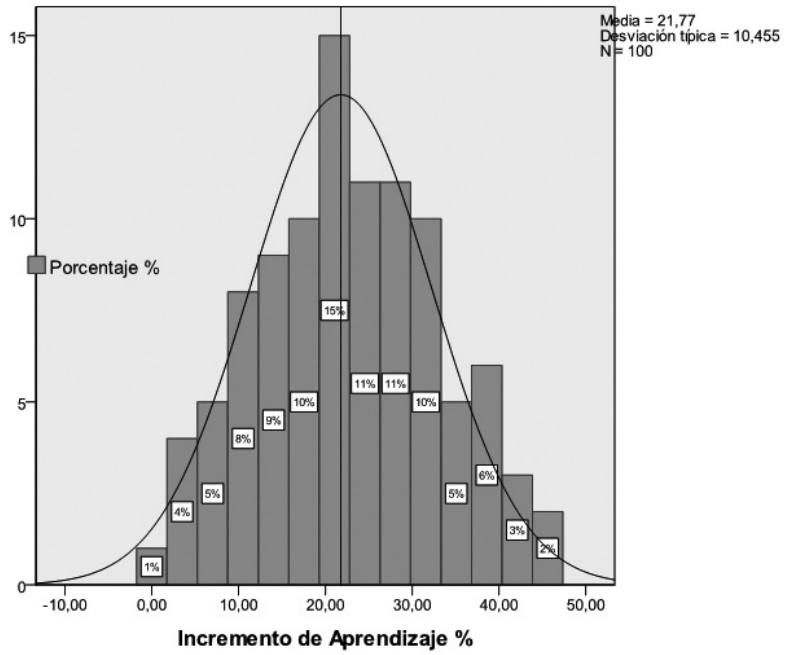


Figura 3. Histograma de la variable ΔA y curva normal de distribución superpuesta. Análisis por Ítems

Con los resultados anteriores podemos dar respuesta a las preguntas referentes a los objetivos específicos marcados al comienzo de esta investigación:

Resultados respecto a los objetivos específicos 1 y 2: ¿Qué porcentaje de los ítems de un test tienen un ΔA superior a un determinado nivel? ¿Qué porcentaje de los ítems de un test tienen un ΔA dentro de un Rango determinado? En las figuras 4 y 5 se muestran los resultados a estos objetivos.

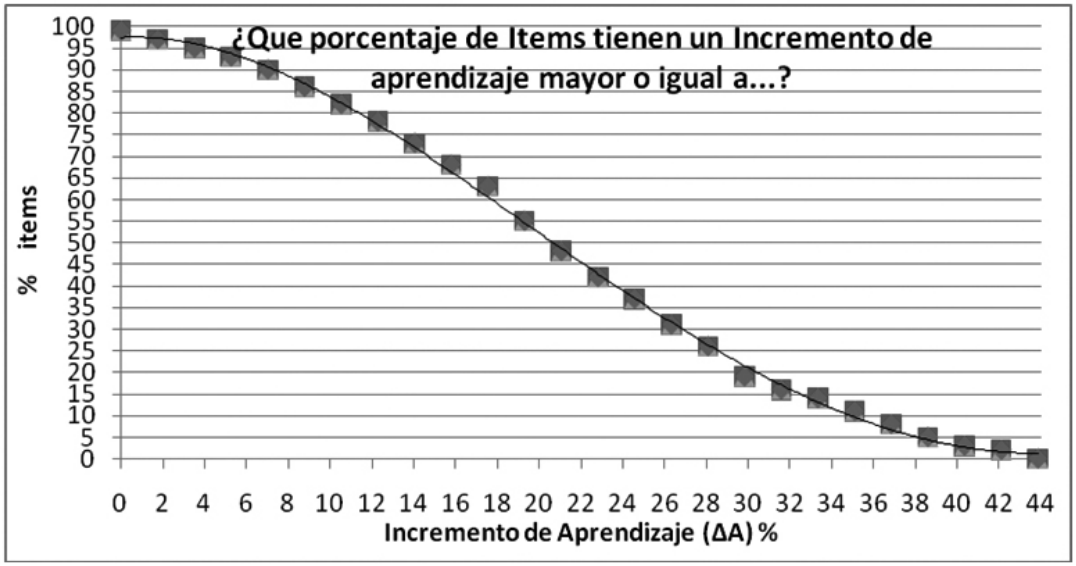


Figura 4. Porcentaje de ítems cuyo ΔA es superior a un cierto nivel representado en el eje horizontal

En la Figura 4 podemos leer qué porcentaje de items tienen un incremento de aprendizaje superior a un cierto valor respresentado en el eje de las X. Por ejemplo, podemos apreciar cómo, cuando el test es contestado por los alumnos del grupo experimental, el 60% de los items tiene un incremento de aprendizaje superior al 18%. En la Figura 5 se representa en un histograma el porcentaje de ítems que tienen un incremento de aprendizaje dentro de cada rango. Por ejemplo, resaltamos que los mayores valores de los porcentajes obtenidos se encuentran en el intervalo del 20 % al 30 %.

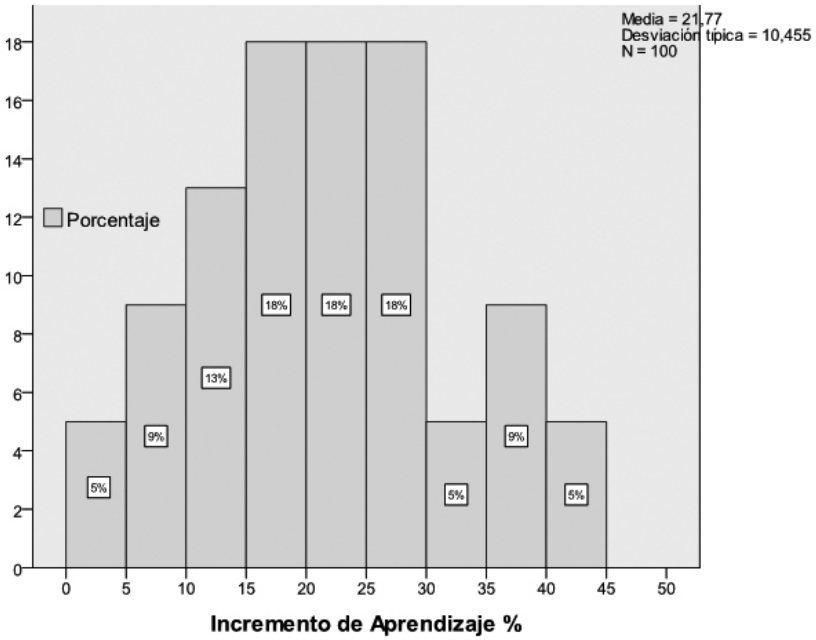


Figura 5. Porcentaje de ítems frente al ΔA para un rango determinado

Resultados respecto a los objetivos específicos 3 y 4: Elegido un determinado Ítem, de un test de conocimientos realizado a un grupo de alumnos que utilice mapas conceptuales, ¿Cuál es la probabilidad de que su ΔA sea superior a un determinado nivel? ¿Cuál es la probabilidad de que su Incremento de Aprendizaje (ΔA) esté dentro de un Rango

determinado? En la Tabla 3 se muestran los resultados a estos objetivos.

Ejemplo de cálculo de la Probabilidad de que el ΔA de un determinado ítem esté:			
Dentro de un cierto rango		Sea superior a un cierto nivel	
ΔA en el Rango…	Probabilidad %	ΔA > a …	Probabilidad %
[0%,5%]	3%	5%	98%
[5%,10%]	8%	10%	95%
[10%,15%]	13%	15%	87%
[15%,20%]	17%	20%	74%
[20%,25%]	19%	25%	57%
[25%,30%]	16%	30%	38%
[30%,35%]	12%	35%	22%
[35%,40%]	6%	40%	10%
[40%,45%]	3%	45%	4%
[45%,50%]	1%	50%	1%

Tabla 3. Cálculo de la probabilidad de encontrar un determinado Ítem cuyo ΔA este dentro de un rango (columnas 1 y 2) o sea superior a un determinado nivel (columnas 3 y 4)

Estos resultados nos indican, por ejemplo, que existe un 74% de probabilidad de que el incremento de aprendizaje de un determinado ítem sea superior al 20% o que el rango cuyo incremento de aprendizaje tiene mayor probabilidad es el comprendido entre el 20% y el 25%.

5 Conclusiones

Los resultados de esta investigación confirman la hipótesis general planteada al comienzo de este estudio, ya que se han encontrado diferencias significativas entre las medias de las calificaciones de los grupos experimental y de control. Estos resultados nos indican que dicha diferencia en el aprendizaje obtenido por los alumnos es consecuencia de la metodología didáctica que se ha llevado a cabo en el grupo experimental mediante la utilización de los mapas conceptuales y de CmapTools. Por ejemplo, podemos afirmar con un intervalo del confianza del 95%, es decir, con un margen de error inferior al 5%, que el incremento de aprendizaje medio obtenido en cada ítem por los alumnos que utilizan como metodología de aprendizaje los mapas conceptuales para el estudio de las fibras ópticas, frente al obtenido por los alumnos que no usan mapas conceptuales está comprendido entre el 18,89% y el 24,65%. Los resultados obtenidos nos permiten afirmar que la aplicación de una metodología de enseñanza basada en la utilización de los mapas conceptuales y de la herramienta CmapTools ayuda a incrementar un promedio de un 21,77% los resultados obtenidos para el estudio de las fibras ópticas.

Para reforzar esta investigación y aumentar el nivel de confiabilidad, se ha realizado un análisis similar al aquí expuesto pero en relación a cuanto más aprenden los alumnos en lugar de a cuanto más se aprende del tema estudiado, resultados que se muestran en otra de las contribuciones a este congreso: “Determinación experimental del incremento de aprendizaje obtenido mediante la utilización de mapas conceptuales y CmapTools. Comparación de la cantidad aprendizaje obtenido por los alumnos utilizando mapas conceptuales y sin utilizarlos”.

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DIFFICULTY OF TEXTS IN UPPER-SECONDARY SCHOOL BIOLOGY TEXTBOOK – USING CONCEPT MAPS FOR ANALYZING STUDENTS NEW KNOWLEDGE

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Abstract. Textbooks play an important role in science classrooms and it is essential to investigate the reading levels of textbooks, particularly in the area of the sciences. The main objectives of the study were: to explore the number of new concepts in the learning text for students and to analyze the difficulty of text; to explore the acquisition of new knowledge by the students using the „expert" concept maps; and to compare gender differences and students' with different beliefs in their own academic abilities in science. 118 students from urban secondary level schools in Estonia participated in this study. This study revealed that a lot of scientific concepts in twelve-grade biology textbooks (Viikmaa, Tartes, 2008) were unknown and difficult for Estonian upper-secondary students. The students had difficulties with identification of 98 concepts from one lesson. There were many students, who did not know the meaning of more than 15 terms in learning text. Students were classified by beliefs in their own academic abilities into three clusters. A significant difference was found between these three attitudinal groups. Students with above average positive beliefs in their own academic abilities tended to use such concepts as hybridomas, identification of pregnancy, reproductive capacity, strange proteins, monoclonal antibodies, antigens, leukocytes more correctly in completing of "expert" concept map. In the most cases the gender differences tended to be not significant.

1 Introduction

Textbooks play an important role in science classrooms and it is essential to investigate the difficulty levels of textbooks, particularly in the area of the sciences. Merzin (1987) have studied the difficulty of science textbooks. The results suggested that there was a general tendency for school science texts to be over demanding on students' abilities. TIMSS 2003 revealed that on average 80 % of Estonian students taught by science teachers reported using a textbook as primary basis of their lessons and 20% as a supplementary resource (Martin, et al., 2004). If the teachers follow the order and contents of the textbooks and if the textbooks are written very academically, in the lessons the main approach is to deal with concepts of knowledge.

A variety of methods have been used to examine students' understandings and to detect alternative conceptions in biology and science education in such as multiple choice items (e.g. Odom, 1995), using analogy in teaching (e.g. Rule & Furletti, 2004), using the drawing (Özsevgec, 2007), and so on. To promote meaningful learning, Novak (1997) recommend that educators use concept maps as a didactic resource.

2 Theoretical background

Studying the sciences requires an understanding of two things: terminology and concepts. Science textbooks are the ultimate source of science knowledge in many science classrooms. (Chiapetta, Sethna, & Fillman 1991; Shamos, 1995; Henno, 2008). Textbooks often present enormous amount of information (Chiapetta, Sethna,& Fillman 1993; Linn, Clement, Pulos, & Sullivan, 1989) and may give only superficial coverage, which discourages conceptual thinking, critical analysis, and evaluation (Penney, Norris, Phillips, & Clark 2003).

Teachers in Estonia can have an influence on what kind of science textbooks should be ordered. After the restoration of independence in 1991 in Estonia and the implementation of the new curricula after 1996, more than 200 new textbooks and workbooks in science subjects for Estonian basic and secondary schools were developed (Henno, 2008), but it is crucial to realize that Estonian current biology textbooks have some shortcomings.

Teaching upper-secondary school students about cell and molecular biology can be a challenge for a teacher when she/he wants to overcome rote learning of facts without a deeper understanding. The basis for the study of the applied biology is presented in Estonian National Curriculum (Estonian Government, 2002). Within the upper-secondary bio-

logy syllabus, the subject matter of cell and molecular biology is introduced progressively from grade 11th to grade 12th. Different aspects with greater depth of understanding are covered in applied biology lessons in grade 12. Students are expected to master an understanding of basic concepts, content, and terminology in applied biology. Teachers must contextualize the role of textbooks within effective instructional practices.

According to psychologist David Ausubel, language plays a key role in the acquisition of concepts (1968). Joseph Novak argues that "concepts" are what we think with. If we cannot get our concepts clarified and organized; our thinking remains muddled" (1977). What comes to difficult topics – whether difficult for the students as determined by the teacher's previous experience, or difficult for the teacher because of his/her background – using an "expert skeleton" concept map is an alternative. An "expert skeleton" concept map has been previously prepared by an expert in the topic, and permits students to build their knowledge on a solid foundation. "Expert skeleton" concept maps serve as a guide or scaffold or aid to learning in a way analogous to the use of scaffolding in constructing or refurbishing a building (Novak & Cañas, 2006).

Assessment is an integral part of teaching and learning, providing feedback on progress through the assessment period to both learners and teachers. Concept maps can be used for showing the topics/contents, in introducing a topic to the students and for evaluation or assessment (Rice, Ryan & Samson, 1998; Novak, Mintzes, & Wandersee, 2000; Henno, Reiska, 2008).

Learning requires a judgment of the difficulty of a task and the ability to accomplish it. Confidence in abilities in various subjects can influence students' motivation, learning behaviors and general expectations for their future. Positive self-concept can be seen as a desirable outcome variable of education (Branden, 1994). Science achievement and self-concept are key components of scientific literacy. Self-concept measures the general level of belief that students have in their academic abilities. Students' academic self-concept correlates with student success. According to PISA 2006 result, in 48 of the participating countries (including all of the OECD countries) there was a positive association between students' self-concept in science and student performance in science (OECD, 2007: 139).

This paper examined the research question: how can concept mapping as an assessment tool be used for identifying students' knowledge and misunderstandings about the cell and molecular biology.

The main objectives of the study were:

- to explore the number of new concepts in the learning text for students and to analyze the difficulty of text for students;
- to explore the acquisition of new knowledge by the students using the "expert" concept maps;
- to compare gender differences;
- to take into account students' beliefs in their own academic abilities in science to compare, how self-concept connected with student success to finalize "expert" maps.

3 Methodology and data collection

The study of this research took place during the school year 2008/2009, in the twelve grade taught by two biology teachers in urban upper-secondary level schools in Estonia. A total of 118 twelve-grade students, 84 (71.2%) were girls and 34 (28.8%) boys, participated in the study. For this survey the students were asked to bring out all unknown concepts in lesson material "Hybridoma technology and production of monoclonal antibodies" from the 12th grade biology textbook ("Biology for upper-secondary schools II. Applied biology. Human biology" published in 2008). The study consisted of three sessions. At the first step of the study students were given 15 minutes to read carefully a new text "Hybridoma technology and production of monoclonal antibodies". In accordance with the instructions students were asked to circle all scientific concepts they did not remember and underline all concepts, they did not know.

In the next phase the teacher explained the new topic with a Power Point presentation. After the classroom instructions, in the end of lesson, the students` understanding was assessed by using the "expert" concept maps. Students were asked to complete a partially constructed concept map ("expert" map) and an additional attitudinal questionnaire.

Students could not use their textbooks and notes from power point presentation with them when they completed the expert concept-map.

The "expert" concept map as learning and assessment material was drafted by the authors using CmapTools program. This concept map is illustrated in Figure 1. Nine boxes (with bold text inside in Figure 1) were empty for students and students had to fill these blank boxes on their own with concepts from the text. No linking words were left empty. The choice of the nine empty concept boxes was random, but it was meant that the empty boxes would not be sequentially.

The self concept questionnaire included an item battery measuring the students' self-belief as science learners. The measures were taken from a related questions presented in PISA 2006. For attitudinal questions measuring students' beliefs in their own academic abilities in science, students were asked to express their level of agreement using one of the following responses: "strongly agree", "agree", "disagree" or "strongly disagree". The study included 5 items to measure students' science self-concept: How much do you agree with the statements below?

1. I can usually give good answers to test questions on school science topics.
2. I learn school science topics quickly.
3. School science topics are easy for me.
4. I can easily understand new ideas in school science.
5. I can understand the concepts very well.

Sixth question was about difficulty of text: Learning text "Hybridoma technology and monoclonal antibodies" was comprehensible.

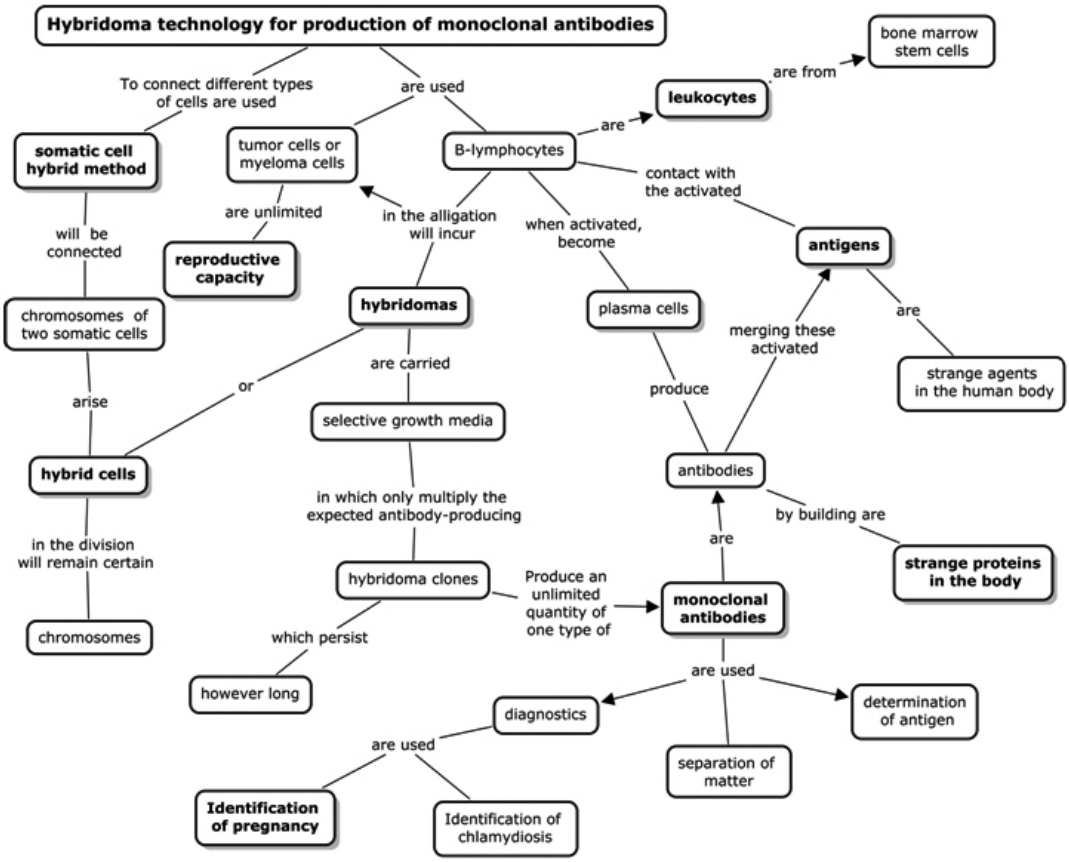


Figure 1. An example of a expert constructed concept map to show how the hybridoma technology is used for production of monoclonal antibodies

For this study, a quantitative approach was adopted. Students' completed "expert" concept maps are assessed mainly counting valid and invalid concepts. The scientific terms from the text mentioned or not mentioned by the students were coded. Descriptive statistics was used to determine frequencies of difficulty, moderate and easy biology concepts as perceived those students. Test of significance were undertaken using t-test, chi-square statistic, ANOVA and cluster analysis.

4 Results

Bordt, et al., have shown (2001) that at the junior high school level many students begin to lose interest in science or develop the view, that science is too hard. Yager`s (1983) review of 25 the most commonly used science texts in K-12 classrooms indicated that more new science words were introduced in those texts than foreign language words in foreign language texts. We found the same tendencies. A total number of words in learning text were 782 (including 186 scientific biology terms). The study revealed that students had difficulties with identification of 98 concepts. There were many students (41), who did not know the meaning of more than 15 terms in the text. Students circled or underlined 96 concepts. The most frequently mentioned unknown and forgotten concepts were: B-lymphocytes; choriogonadotropin; hypophysis; lymphocytes; myeloma; pathogen; plasma cell; somatic cell hybrid method; toxins. Chi-Square($\chi 2$) test was used to examine differences between gender. In most cases the results of independent t-test did not indicate significant difference between genders. Only in some cases: hybridoma technology for production of monoclonal antibodies; chromosome; chlamydiosis; chlamydia test; chromosome the significant difference was found between genders. Males were claimed to know these concepts less.

Students form views about their own competences and learning characteristics. Self-concept measures the general level of belief that students have in their academic abilities and academic self-concept strongly correlates with student success. Their evaluation is based on their position relative to other students and their relative performance on different school subjects (Marsh, Byrne & Shavelson 1988). On average, only 41% of students reported that they strongly agreed or agreed that they could usually give good answers in science tests. Overall, a large proportion of students said that they were not confident in learning science, 56% of students reported that they did not agree that they learned school science topics quickly, 64% of students understood concepts or 62% of students understood new ideas very

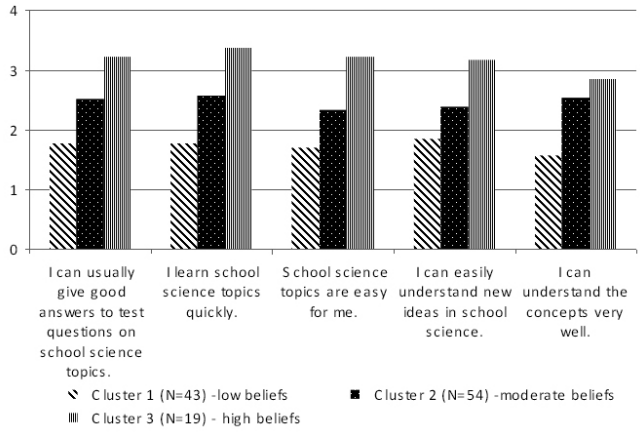


Figure 2. Students demonstrated beliefs in their own academic abilities.

well. Furthermore, 35% agreed that school science topics were easy. On average, only 26% of students agreed that the learning text „Hybridoma technology and monoclonal antibodies" was comprehensible. The t-test was used to study gender differences. The results of independent-t test indicated no differences among groups in self-reported attitudes.

Cluster analysis was used to identify natural groupings within the study cohort. Students were classified by beliefs in their own academic abilities into three clusters. Cluster 1 (Nstud=43) demonstrated low beliefs in their own academic abilities. Cluster 2 (Nstud=52) demonstrated moderate beliefs and Cluster 3 (Nstud=19) above the average positive attitudes, greater confidence than students in the other two Clusters (Figure 2). The students in the third group

agreed in the comparison with other groups much more with the statement that learning text "Hybridoma technology and monoclonal antibodies" was comprehensible.

The ANOVA function of SPSS was used to determine statistically whether these groups exhibit different patterns in using valid concepts in "expert" concept maps. One way ANOVA revealed significant differences between these three attitudinal groups. ANOVA revealed a significant main effect for concept hybridomas ($F=3,97$, $p < 0,022$), identification of pregnancy ($F=4,27$, $p < 0,016$), reproductive capacity ($F=3,33$, $p < 0,039$), strange proteins ($F=7,03$, $p < 0,001$), monoclonal antibodies ($F=6,95$, $p < 0,001$), antigens ($F=3,50$, $p < 0,033$), leukocytes ($F=3,27$, $p < 0,042$). This means that students with above average positive beliefs in their own academic abilities tended to use these concepts more correctly in completing "expert" concept map. ANOVA did not reveal a significant main effect for concepts: hybrid cells, somatic cell hybrid method. The results of Chi-Square ($\chi 2$) test did not indicate the significant differences between frequencies of genders using the correct concept. The only difference was found with the concept: somatic cell hybrid method. Valid concepts were given by 38,1% of females and 23,5% of males.

An analysis of the "expert" concept maps revealed that students demonstrated an understanding about focus question: "Hybridoma technology and production of monoclonal antibodies". The most known concepts were: antigens (78% of students have mentioned) and hybridomas, (74%), and identification of pregnancy (58%). The most unknown concept was monoclonal antibodies (26%). Most commonly students (40%) wrote an invalid term in place of concept monoclonal antibodies. Blank was most often left in place of a concept strange proteins and somatic cell hybrid method (Table 1).

	Correct	Incorrect	Blank box
antigens	79,8%	6,1%	14,0%
hybridomas	73,9%	12,6%	13,4%
identification of pregnancy	57,5%	5,3%	37,2%
leukocytes	57,9%	11,2%	30,8%
reproductive capacity	61,5%	6,3%	32,3%
hybrid cells	50,0%	13,2%	36,8%
strange proteins	38,3%	12,2%	49,6%
somatic cell hybrid method	34,2%	16,2%	49,6%
monoclonal antibodies	26,3%	40,4%	33,3%

Table 1. The percent of students using valid and invalid concepts in finishing partially generated concept map by expert.

Table 2 present the percent of students with different beliefs in their own academic abilities using valid concepts in finishing partially generated concept map by expert

Concepts	Low beliefs in their own academic abilities	Moderate beliefs in their own academic abilities	High beliefs in their own academic abilities
somatic cell hybrid method	25,6%	37,0%	47,4%
hybrid cells	41,9%	55,6%	57,9%
reproductive capacity	55,8%	72,2%	89,5%
hybridomas	62,8%	81,5%	89,5%
leukocytes	51,2%	61,1%	84,2%
antigens	69,8%	83,3%	94,7%
strange proteins	25,6%	40,7%	73,7%
monoclonal antibodies	25,6%	40,7%	63,2%
identification of pregnancy	44,2%	63,0%	78,9%

Table 2. The percent of students in different attitudinal clusters using valid concepts in finishing partially generated concept map by expert.

5 Summary

Textbooks play an important role in science classrooms and it is essential to investigate the reading levels of textbooks, particularly in the area of the sciences. This study revealed that most scientific concepts of the learning text “Hybridoma technology and production of monoclonal antibodies“ in twelve-grade biology textbook (Viikmaa, Tartes 2008) were unknown and difficult for Estonian upper-secondary students. It was found that students had difficulties with identification of 98 concepts. The learning text for the student's should be comprehensible. German experts evaluating the learning texts have shown that the texts can be characterized by four essential characteristic: simplicity, structured, brevity, attraction (Groeben, 1982). This textbook lists lesson-by-lesson content objectives, main ideas, important concepts, and comprehension questions that students need to understand, but the analysed section of applied biology textbook is written in a way, as students have as much prior knowledge as authors do. The nowadays Estonian students' lack of interest and low motivation to learn biology may be related to the increasingly sophisticated materials in biology textbooks.

Students were classified by beliefs in their own academic abilities into three clusters. In the comparison with other groups , students in the third group agreed much more with the statement that learning text “Hybridoma technology and monoclonal antibodies“ was comprehensible. The results of Chi-Square($\chi 2$) test did not indicate significant differences between genders. This means that the learning text was difficult for both group – for males and females.

Concept mapping was used in the biology classroom to assess students' present knowledge. It was intended to determine whether the use of “expert” concept maps in the classroom as an assessment tool can identify and address specific misconceptions. One way ANOVA revealed significant differences among these three attitudinal groups. Students with high positive beliefs in their own academic abilities tended to use concepts hybridomas, identification of pregnancy, reproductive capacity, strange proteins, monoclonal antibodies antigens, leukocytes more correctly in completing the “expert“ concept map than the lower groups.

Studying biology, using strategies to learn terminology and effectively conceptualizing scientific processes will help students understand the subject. To learn new concepts and for better understanding it is very likely helpful to use the visualization of basic structures or graphically describe the phenomenon. The work with concept maps, in the classroom, requires time and mastery of the elaboration process. Based on these evidences we continue our research on concept mapping as an assessment tool in science education.

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EFECTOS DE UN APOYO MEDIACIONAL EN TAREAS DE ELABORACIÓN DE MAPAS CONCEPTUALES EN ESTUDIANTES UNIVERSITARIOS CON DIFERENTES NIVELES DE HABILIDADES LECTORAS

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Abstract. En este trabajo se examina la influencia de las habilidades lectoras de estudiantes universitarios en tareas de elaboración de mapas conceptuales y se analizan los efectos de una serie de apoyos mediacionales en el rendimiento alcanzado en esta tarea. Para ellos se valoraron, de manera taxonómica, mapas conceptuales sobre un texto expositivo (capítulo de libro) que construyeron estudiantes universitarios, antes y después de recibir el mencionado apoyo mediacional. Participaron en el estudio diecisiete estudiantes universitarios que, de acuerdo a sus habilidades de comprensión lectora, fueron agrupados, según el rendimiento que alcanzaron en pruebas de comprensión lectora, en dos condiciones: a) estudiantes con bajo nivel; y, b) estudiantes con nivel medio. Se proporcionaron a ambas condiciones una serie de apoyos mediacionales, antes durante y después de la elaboración de los mapas conceptuales. Se valoraron los mapas conceptuales iniciales y finales de manera taxonómica empleando la herramienta Cmap Analysis Tool (Cañas, 2010, en preparación). Los resultados muestran la existencia de diferencias significativas en las características topológicas de los mapas conceptuales iniciales elaborados por los estudiantes con bajo nivel de habilidades lectoras. En tanto que las diferencias significativas favorecen a los estudiantes con comprensión lectora media, cuando se consideran los cambios en dichas características topológicas entre las versiones iniciales y finales de los mapas, después de habérseles proporcionado apoyos mediacionales. Se presenta también un análisis cualitativo, en el que se comparan aspectos estructurales con aspectos semánticos en los mapas iniciales y finales elaborados por dos casos de estudiantes prototípicos. Se señalan algunas implicaciones y limitaciones del estudio.

1 Introducción

Como es bien sabido los mapas conceptuales son herramientas gráficas para organizar y representar conocimientos (Novak y Cañas, 2008). En el campo de la comprensión lectora los mapas conceptuales han sido utilizados no sólo como herramientas de evaluación, es decir, para examinar y valorar los niveles de comprensión que alcanzan los estudiantes cuando leen un texto (Anderson y Huang, 1989; Hay, 2007; Rice, Ryan y Samson, 1998); sino también, y muy especialmente, como herramientas de aprendizaje, es decir, como una estrategia instruccional para promover la comprensión de diferentes tipos de textos, sobre todo textos expositivos (Chang, Sung y Chen, 2002; Hilbert y Renkl, 2008; Iraizoz Sanzol y González García, 2006; Liu, Chen y Chang; 2010; Oliver, 2009). Sin embargo, la elaboración de mapas conceptuales no resulta una tarea sencilla. Los aprendices, en particular los novatos en la elaboración de mapas conceptuales, pueden experimentar sobrecarga cognitiva (Reader y Hammond, 1994; Chang et al., 2002); y, por consiguiente, se les dificultaría aprovechar las potencialidades de los mapas conceptuales. Podría pensarse que algunos factores individuales, tales como un apropiado nivel de conocimientos previos de dominio específico o bien un buen nivel de comprensión lectora, permitirían a los aprendices afrontar con éxito las demandas cognitivas y metacognitivas que requiere esta clase de tarea; no obstante, algunos estudios no han encontrado diferencias significativas en el rendimiento que logran estudiantes con diferentes niveles de comprensión lectora cuando elaboran mapas conceptuales a partir de textos expositivos complejos (Oliver, 2009). En este estudio se analizan y valoran, de manera taxonómica, mapas conceptuales sobre un texto expositivo (capítulo de libro) que construyen estudiantes universitarios con diferentes niveles de comprensión lectora, antes y después de recibir una serie de ayudas mediacionales, examinándose también los efectos de dichas ayudas en el rendimiento que alcanzan en la elaboración de mapas conceptuales.

2 Mapas conceptuales y comprensión de textos expositivos

La comprensión es un proceso complejo que puede desenvolverse en distintos planos: uno superficial en el que las palabras y las frases se relacionan para formar una representación proposicional que en articulación con otras daría lugar a una representación de la estructura semántica del texto; y otro más profundo en el que la información que pro-

vee el texto se integra con el conocimiento previo. Así, comprender es construir una representación mental o modelo situacional que recoja el significado global de un texto en integración con los conocimientos previos (Kintsch, 1994). Es decir, comprender un texto implica tener en cuenta que no toda la información resulta igualmente importante y que las ideas guardan entre sí una relación precisa. La comprensión, por lo tanto, va más allá de la simple reproducción de información. Requiere de la activación de estructuras de conocimiento previas a las que asimilar la nueva información, por lo que tiende a producir cambios en esas estructuras (Sánchez, 1998).

Los estudios en la comprensión de textos han identificado diferentes niveles de procesamiento correspondientes a también diferentes niveles de representación de la información textual. Son seis los niveles de representación que se tienen en cuenta, según Rouet (1999). Los primeros tres niveles, considerados prerrequisitos de la comprensión, son: a) fonológico o representación de grafemas basada en información recibida; b) representación del significado de las palabras y de las funciones; c) representación de estructuras lógicas y gramaticales. Los tres niveles siguientes, por su parte, son considerados los niveles de comprensión propiamente dichos y han sido planteados por Kintsch (1994): d) representación del significado literal de las sentencias (microestructura proposicional), e) representación del sentido global y de las relaciones entre diferentes pasajes del texto (macroestructura proposicional); f) representación acerca de lo que es el texto (modelo situacional), en la que se integran tanto aspectos textuales como también los conocimientos previos de los aprendices acerca de la situación a la que se refiere el texto.

Ahora bien, cuando un aprendiz elabora un mapa conceptual durante la lectura de un texto expositivo necesita poner en juego e integrar procesos "bottom-up", es decir, abajo hacia arriba, junto con procesos "top-down", de arriba hacia abajo. Por ejemplo, tal como señala Liu et al., 2010, se requiere, una vez que se ha captado el significado de palabras y proposiciones, identificar la idea principal del texto, a partir de la cual se establecen enlaces con otras proposiciones, organizándolas de manera jerárquica para construir una idea global del texto. A la par, la construcción de un mapa conceptual demanda activar los esquemas previos de conocimiento y establecer nuevos enlaces inferenciales que van más allá de lo que el texto dice. De esta manera en la tarea de mapping el aprendiz va revisando las relaciones entre los conceptos, a la vez que recuerda y organiza la información que presenta el texto integrándola con sus conocimientos previos.

Por consiguiente, siguiendo a Hilbert y Renkl (2008), los mapas conceptuales como estrategia para la comprensión y el aprendizaje a partir de textos permitirían cubrir cuatro funciones clave: a) una función de elaboración: que posibilitaría relacionar los conocimientos previos con la nueva información del texto para determinar las ideas principales y sus relaciones con otras ideas; b) una función de reducción: que permitiría identificar y retener las ideas centrales que configuran el esquema global del texto; c) una función de coherencia: al respecto, el mapa conceptual favorecería la construcción de una estructura coherente del texto, a la vez que sería útil para identificar las rupturas en la coherencia textual; y, por último, estrechamente relacionado con lo anterior, d) una función metacognitiva: ya que favorecería la detección y reparación de los sesgos y lagunas que pudieran aparecer en el propio procesos de comprensión.

Sin embargo, la elaboración de buenos mapas conceptuales no resulta una tarea sencilla. Es muy probable que los aprendices que recién se inician en esta clase de tareas tengan dificultades y experimenten una sobrecarga cognitiva. Por ejemplo, en estudios recientes Hilbert y Renkl (2008, 2009), identificaron algunos déficits específicos en mapeadores novatos, tales como dificultades para poner en juego estrategias de planeación y control de la tarea, además de inconveniente a la hora de etiquetar los enlaces entre los nodos de conceptos. De ahí que algunos estudios como los realizados por Chang et al. (2001, 2002), hayan mostrado la necesidad de proporcionar ayudas instruccionales, dado que los estudiantes que elaboran mapas como una tarea abierta, sin apoyo instruccional previo, se ven afectados en su rendimiento en comprensión de textos.

Asimismo, en principio podría pensarse que algunos factores individuales, tales como un apropiado nivel de conocimientos previos de dominio específico o bien un buen nivel de comprensión lectora, permitirían a los aprendices afrontar con éxito las demandas cognitivas y metacognitivas que requiere esta clase de tarea. Sin embargo, diferentes estudios no han encontrado diferencias significativas en el rendimiento que logran estudiantes con diferentes niveles de comprensión lectora cuando elaboran mapas conceptuales a partir de textos expositivos complejos (Oliver, 2009).

No obstante, se hace necesario contar con mayor evidencia empírica, tanto acerca de la manera en que influyen variables como las habilidades de comprensión lectora de los estudiantes en la elaboración de mapas conceptuales, como también respecto al diseño y la validación de propuestas instruccionales y/o mediacionales que apoyen dicha tarea.

2.1 Un modelo mediacional centrado en mapas conceptuales

En el sistema de ayudas se contemplan varios elementos propuestos por Novak y Cañas (2004) en la formulación de un modelo educativo con fundamento en el constructivismo y en el uso de mapas conceptuales y CmapTools (IHMC, 2010). En primer lugar, en dos sesiones previas a la tarea de elaboración de mapas conceptuales se llevaron a cabo las siguientes actividades: a) mediante una clase expositiva, se realizó una breve introducción al modelo mediacional centrado en mapas conceptuales y se explicaron sus notas distintivas, presentándose la técnica de elaboración del mapa conceptual; además, se discutieron algunas de sus aplicaciones y fundamentos psicopedagógicos y se comentó sobre su relevancia de utilizar esta herramienta en el ámbito universitario; y, b) se les instruyó en técnicas de subrayado y notas de conceptos que podrían resultar relevantes para la elaboración de mapas conceptuales a partir de textos expositivos; asimismo, en dicha tarea de elaboración de mapas conceptuales se subrayó la importancia de la pregunta de enfoque, destacándose su incidencia para determinar los conceptos relevantes a incluir en el mapa conceptual. Junto a ellos se dieron las instrucciones básicas para emplear Cmap Tools de acuerdo a la propuesta de HIMC (año), llevándose a cabo una práctica de modelado sobre contenidos de la vida cotidiana.

A continuación, en una tercera sesión los estudiantes los estudiantes pasaron a elaborar los mapas conceptuales con la herramienta Cmap Tools. En el inicio de esta sesión se presentó una pequeña contextualización de la lectura a realizar, explicándose, por ejemplo, dónde se había publicado el texto a leer, quién era el autor, algunos aspectos del lenguaje utilizado en el texto. Los alumnos realizaron la lectura en el espacio del taller. En esta sesión los estudiantes contaron con la asistencia del profesor cuando era requerida, para solucionar dudas respecto a CmapTools.

En una cuarta sesión, se procedió a revisar la primera elaboración o versión del mapa conceptual. En esta sesión se siguieron las siguientes estrategias mediacionales: a) revisión directa por parte del profesor; b) presentación ante el grupo, en la que se proponían algunas observaciones de carácter técnico del mapa conceptual y se aprovechaban las proposiciones en el mapa conceptual para abordar un tema; c) recomendaciones y comentarios en CmapServer, el profesor comentaba algunos mapas dejando notas a los estudiantes.

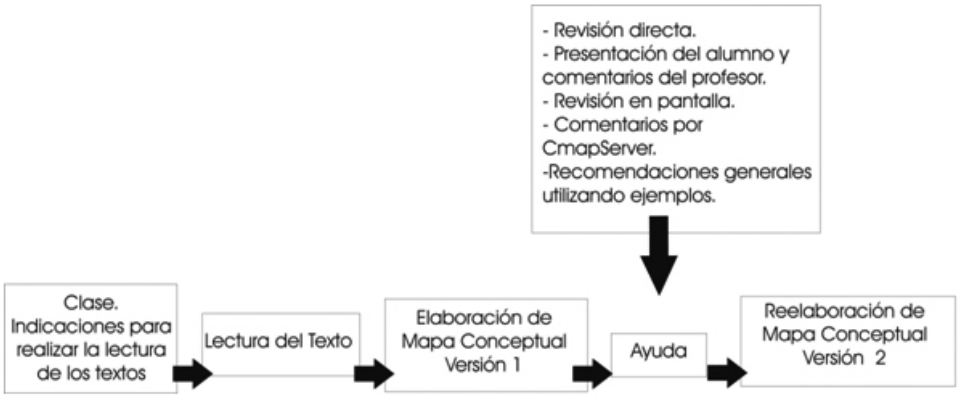


Figura 1. Modelo de elaboración y ayuda para la reelaboración

Finalmente en la quinta sesión los estudiantes elaboraron la versión final de su mapa conceptual acerca del capítulo de libro y entregaron los mapas conceptuales mediante un portafolio de evidencias, presentaron dos versiones de su mapa conceptual: una versión inicial y una versión final, que es resultado de la reelaboración que a partir de la ayuda proporcionada.

En este estudio se examina si el rendimiento en la elaboración de mapas conceptuales varía en función de las habilidades lectoras de los estudiantes y se analizan los efectos de una serie de ayudas instruccionales en dicho ren-

dimiento. Para ellos se valoraron, de manera taxonómica, mapas conceptuales sobre un texto expositivo (capítulo de libro) que construyeron estudiantes universitarios, antes y después de recibir el mencionado apoyo instruccional. Los estudiantes fueron agrupados, según el rendimiento que alcanzaron en pruebas de comprensión lectora, en dos condiciones: a) estudiantes con bajo nivel; y, b) estudiantes con nivel medio. Se proporcionaron a ambas condiciones una serie de apoyos mediacionales, antes durante y después de la elaboración de los mapas conceptuales. Se valoraron los mapas conceptuales iniciales y finales de manera taxonómica empleando la herramienta Cmap Analysis Tool (Cañas, 2010, en preparación).

3 Metodología

3.1 Participantes y diseño

Los participantes fueron 17 estudiantes universitarios con bajo nivel de conocimientos previos en el dominio específico (15 mujeres y 2 varones). La edad media de los participantes fue de 21 años. Se organizaron dos grupos a partir de los resultados obtenidos en las pruebas de comprensión lectora, estableciendo como punto de corte el percentil 50. El primer grupo, por debajo de la mediana, estuvo compuesto por 8 estudiantes (M=2.25; s=1.16); mientras que el segundo grupo se conformó con 9 estudiantes que alcanzaron puntajes superiores a la mediana en las pruebas de comprensión lectora (M=6.67; s=2.27). Es importante aclarar que estos últimos estudiantes estuvieron lejos de alcanzar los puntajes máximos esperados en estas pruebas (14), por lo que se infiere que se trata de estudiantes en realidad con habilidades lectoras medias. Se trabajo en varias sesiones con los dos grupos siguiendo el modelo mediacional descripto en un apartado anterior. El rendimiento en mapas conceptuales, antes y después de proporcionar las ayudas mediacionales, se valoró utilizando la herramienta Cmap Analysis Tool (Cañas, 2010, en preparación) que proporciona un puntaje referido al nivel de complejidad estructural que presentan estos mapas, es decir, teniendo en cuenta su taxonomía topológica. Se controló previamente el nivel de experiencia en elaboración de mapas conceptuales. Los estudiantes tenían bajo nivel en esta variable, no encontrándose diferencias significativas entre los dos grupos.

3.2 Procedimiento

El estudio han demandado varias sesiones cada una de aproximadamente 90 minutos de duración, durante tres semanas. Antes de iniciar las sesiones referidas al modelo mediacional, se aplicaron los cuestionarios sobre experiencia en elaboración de mapas conceptuales y el cuestionario conocimientos previos sobre el tema específico de los mapas conceptuales y se presentaron a los estudiantes dos tareas de comprensión lectora para su realización. A continuación se llevaron a cabo las 5 sesiones descriptas en el modelo mediacional.

3.3 Materiales

Para valorar las habilidades de comprensión lectora de los estudiantes se emplearon dos tareas. Por un lado, se aplicó la Batería Multimedia de Comprensión (versión abreviada) de Gernsbacher y Varner (1988), adaptada por Díez y Fernández (1997) que permite valorar los niveles de comprensión lectora. En esta prueba se pide a los alumnos que lean un texto informatizado "El regalo más preciado" y que, luego de la lectura, contesten ocho ítems con formato de pregunta de elección múltiple con cinco opciones de respuesta acerca del contenido presentado en ese texto. La prueba seleccionada de la batería multimedia controla el tiempo de presentación del texto, manteniéndolo constante, y también establece un tiempo uniforme (20 segundos) para responder cada uno de los ítems de evaluación. Cada pregunta acertada es contabilizada con un punto hasta alcanzar un máximo de ocho. Además, se administró una tarea de comprensión lectora de un texto expositivo corto y sencillo (111 palabras), en la que se solicita a los estudiantes que después de haber leído el texto durante 120 segundos, señalen las cuatro ideas principales referidas en el texto y elaboren una representación gráfica que relaciones dichas ideas. El puntaje máximo de esta tarea es seis.

El material de aprendizaje consistió en un texto expositivo de 10 páginas (alrededor de 6.500 palabras) sobre el tema "El mapa conceptual: una herramienta para aprender y enseñar". Este texto utiliza un vocabulario sencillo y presenta una serie de marcadores textuales que favorecería la construcción de su esquema global.

Los estudiantes elaboraron los mapas conceptuales con la herramienta CmapTools V. 5 [Aplicación Informática] (HIMC, 2009). Los mapas conceptuales de los alumnos fueron recuperados del CmapServer.

Como señalamos anteriormente, los mapas conceptuales fueron valorados con la herramienta Cmap Analysis Tool (Cañas, en preparación), software orientado a la evaluación de grandes cantidades de mapas conceptuales y por medio del cual se obtiene una medida de la calidad topológica del mapa conceptual. Es decir para examinar la calidad de un mapa conceptual se puede considerar sus características topológicas -como ser estructura jerárquica, tamaño de las etiquetas para los conceptos, presencia de frases de enlace, entre otros- y partir de ellos estimar su nivel de complejidad (Valerio, Leake y Cañas, 2008). La mencionada herramienta permite justamente valorar la complejidad estructural de los mapas conceptuales otorgándoles diferentes niveles con un máximo de 6.

Por otro lado, algunos de los mapas conceptuales iniciales y finales fueron analizados de manera cualitativa, tomando en cuenta sus características semánticas. Para ello se analizaron aspectos relacionado con la corrección de las proposiciones presentadas en el mapa conceptual de acuerdo a lo referido en el texto expositivo, la selección y presentación en el mapa conceptual de las ideas centrales del texto, la pertinencia de la pregunta de enfoque y si podía ser respondida por las proposiciones referidas en el mapa conceptual.

4 Resultados

Para el análisis de resultados se compararon entre sí las dos condiciones, empleando la prueba t de diferencias de medias. En la siguiente Tabla 1 se muestran los puntajes obtenidos por los estudiantes en las dos condiciones: Se encontraron diferencias significativas en el rendimiento en la elaboración inicial del mapa conceptual (características topológicas), a favor del grupo de estudiantes con menores habilidades lectoras $t(14.04) = 2.41$, $p < .05$ (para varianzas desiguales). Después de las ayudas instruccionales los estudiantes de ambos grupos alcanzaron un rendimiento similar. Comparando las variaciones en los mapas los resultados muestran diferencias significativas a favor del grupo con habilidades lectoras medias $t(14.94) = -2.18$, $p < .05$ (para varianzas desiguales); es decir, estos estudiantes después de recibir las ayudas mediacionales incrementaron de manera significativa su rendimiento en la elaboración de mapas conceptuales, considerando sus características topológicas.

	Comprensión lectora		Rendimiento en mapa conceptual inicial		Rendimiento en mapa conceptual final		Diferencia de rendimiento en mapa conceptual	
Grupo con nivel de habilidades de comprensión lectora bajo n = 8	2.25	1.16	4.75	1.28	4.62	1.40	-.12	1.24
Grupo con nivel de habilidades de comprensión lectora medio n = 9	6.77	2.27	3.33	1.11	4.66	1.32	1.33	1.50

Tabla 1. Medias de los puntajes obtenidos por los dos grupos en tareas de comprensión lectora y rendimiento en la elaboración de mapas conceptuales (valoración topológica) antes y después del apoyo mediacional

Asimismo, se consideró conveniente analizar de manera cualitativa –tomando en cuenta sus características semánticas- el tipo de mapas conceptuales que elaboraron dos estudiantes prototípicos para cada uno de los dos grupos.

Así, por ejemplo, en las versiones inicial y final del mapa conceptual elaboradas por R., perteneciente al grupo de estudiantes con nivel bajo de habilidades lectora, se puede observar un patrón de diseño con tres brazos y tres niveles jerárquicos, sin enlaces cruzados. En la ambas versiones recoge proposiciones correspondientes a solamente una parte del texto, práctica que ya ha sido descrita por otros autores (Aguilar Tamayo, et al., 2006). La reelaboración en este caso, exigiría a la estudiante leer más con mayor profundidad el texto, por consiguiente no se observa un cambio en la estructura del mapa, ni tampoco introduce nuevos grupos de conceptos que obliguen a reorganizarlo. De hecho, ambos mapas conceptuales se parecen por su estructura. Considerando esto, es posible inferir que las prácticas comunes superficiales reorientan el objetivo del mapa conceptual, de ahí que sea una herramienta para hacer resúmenes y no para comprender, estudiar o releer los textos.

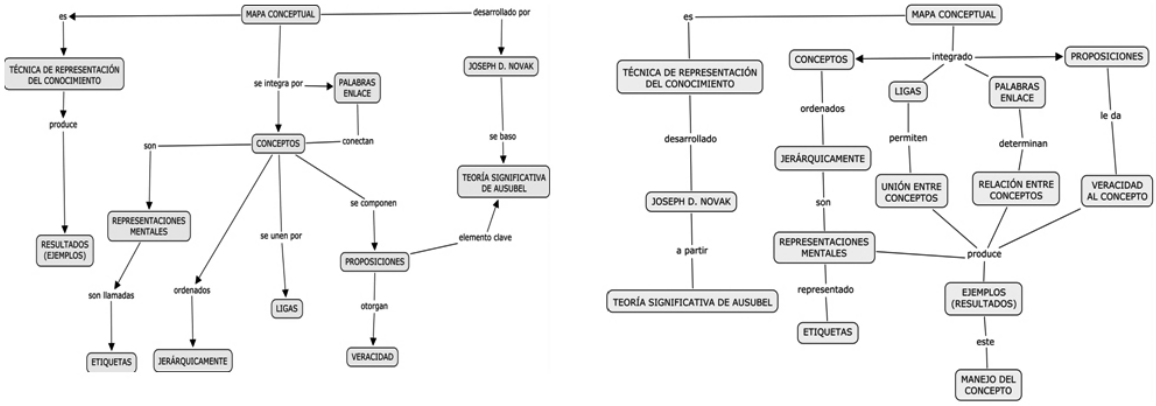


Figura 2. Mapas conceptuales inicial y final de la estudiante R. con bajo nivel de habilidades de comprensión lectora

Respecto a los mapas conceptuales de O., que corresponde al grupo de grupo de estudiantes con nivel medio de habilidades lectora y que, según la valoración taxonómica ha registrado un cambios significativo en su mapa reelaborado, se observa que ambos tiene un orden jerárquico. Sin embargo, en la versión final aparecen enlaces cruzados y se ha modificado la estructura del mapa, introduciendo nuevos grupos de conceptos. En el caso de O., las ayudas conllevan a replantear preguntas y a modificar la estructura del mapa conceptual. Por consiguiente, el mapa conceptual es dinámico. En cambio, pude inferirse que para R. es una estructura estable. El mapa conceptual es para O. un nueva forma de relacionarse con el conocimiento y sus propios procesos de comprensión, en tanto que para R. el mapa conceptual se equipara una técnica, en este caso al resumen, y más aún, lejos de problematizar el proceso de aprendizaje lo evita, evita leer más.

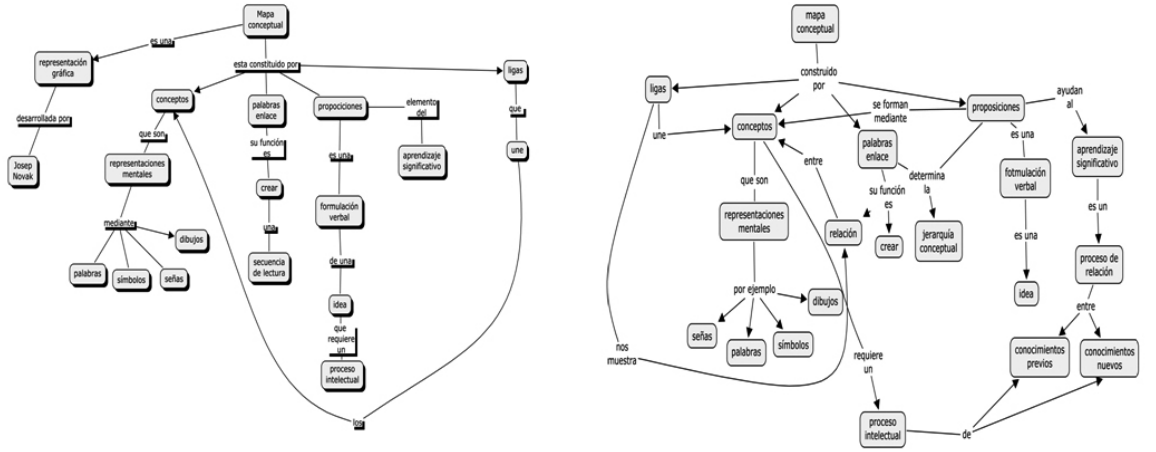


Figura 3. Mapas conceptuales inicial y final de la estudiante O. con nivel medio de habilidades de comprensión lectora

5 Conclusiones e implicaciones

La realización de mejores mapas conceptuales puede estar relacionada a varios elementos, cada uno de ellos podrá tener una relevancia dependiendo de algunos factores individuales, como el nivel de habilidades de comprensión lectora. Además, los datos muestran que la reelaboración es un elemento importante para mejorar tanto topológica como semánticamente un mapa conceptual, por consiguiente es necesario presentar una serie de ayudas que propicien la reflexión y orienten dicho proceso de reelaboración, tal como lo señalan diferentes estudios recientes (Chang et a., 2001; Hilbert y Renkl, 2009; Leopold, den Elzen-Rump y Leutner, 2007).

No obstante, un dato que resultaba en principio inesperado hace referencia al hecho de que los estudiantes con niveles inferiores de comprensión lectora alcanzaban en su primer mapa conceptual puntajes taxonómicos superiores, en comparación con los estudiantes con un nivel medio de habilidades lectoras los alumnos de baja. Pero un análisis cualitativo sobre los casos específicos nos permitió observar que estos mapas conceptuales cumplían con la apariencia del mapa conceptual, que en muchos casos las relaciones proposicionales eran generales y en algunos casos recuperaban la narrativa de los textos sin una reconstrucción de la jerarquía (Aguilar-Tamayo et al, 2006).

Asimismo, el análisis realizado indica que los alumnos con mayor índice de comprensión lectora se benefician de la ayuda mediacional, en comparación a los estudiantes con bajo nivel de habilidades de comprensión lectora.

Estos resultados muestran la necesidad de diseñar sistemas mediacionales que apoyen el proceso de construcción de mapas conceptuales como estrategia para la comprensión de textos expositivos, a la par que tengan en cuenta las necesidades específicas de mapeadores novatos, de acuerdo a sus características individuales.

6 Agradecimientos

Este trabajo es parte de la investigación en progreso “Comprensión multimedia”, que se lleva a cabo con financiamiento de PROMEP-SEP (México) /103.5/07/2674, bajo la responsabilidad técnica del primer autor. Asimismo, la presentación de este trabajo ha sido posible por el proyecto: CONACYT CB-2006/60651, El aprendizaje de conceptos científicos y su evaluación mediante mapas conceptuales, bajo responsabilidad técnica del segundo autor.

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Viña del Mar, Chile, 2010

EL PENSAMIENTO VISUAL EN DISEÑO: EL ROL DE LOS MAPAS CONCEPTUALES EN LA CONSTRUCCIÓN DE MODELOS VISUALES

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Abstract. Este trabajo examina el rol de los mapas conceptuales dentro del proceso de diseño y presenta una metodología de trabajo que ubica a los mapas conceptuales como pieza inicial en el proceso de representación. Los mapas conceptuales se constituyen como gramática visual de base que facilita la creación de posteriores modelos más elaborados, propios de la disciplina del diseño, y materializaciones de los hallazgos del proceso de investigación. En este trabajo revisaremos diversos ejemplos históricos y paradigmáticos en la construcción de imágenes significativas, donde indicamos las correspondencias con el raciocinio visual de los mapas conceptuales. Finalmente presentamos un ejemplo de esta metodología aplicada a la concepción de un modelo visual, que opera como pivote entre "el modelo de lo que es" y "el modelo de lo que debe ser", es decir, construyendo una herramienta de pensamiento crítico y propositivo, propio del ámbito del diseño.

1 Introducción

Dentro del diseño, los modelos visuales son representaciones construidas a partir de los datos generados durante el proceso de investigación. Estas representaciones buscan capturar y comunicar los aspectos más críticos e importantes de la materia en cuestión y deben adaptarse al contexto o encargo de diseño. De modo que puedan constituirse como herramientas que favorezcan, faciliten el análisis y la toma de decisiones, así como revelar patrones ocultos en los datos que nos permitan descubrir estructuras u órdenes previamente ocultos.

Un buen modelo visual requiere un conjunto elaborado de categorías, temáticas o conceptos que son sistemáticamente yuxtapuestos y relacionados para componer un todo integrado, de modo de revelar o explicar algún fenómeno sólo evidente luego de la investigación. La construcción de estos modelos corresponde a un proceso descriptivo que ordena y construye miradas para explicar. Estos modelos son llamados incompletos dentro de la teoría de sistemas (Von Bertalanffy, 1976) pero son altamente valorados en su capacidad de generar correspondencias conceptuales con la realidad. El valor de un modelo radica justamente en estas correspondencias, y son ellas, las que desencadenan el diálogo dentro del equipo de diseño, convirtiendo al modelo en un objeto fronterizo (Bergman, Lyytinen, & Mark, 2007) que facilita la comunicación entre los diversos actores involucrados en un proyecto.

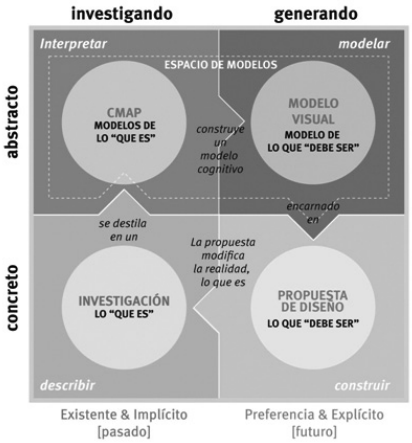


Figura 1. Proceso de Diseño. Elaboración sobre el Modelo Puente de Síntesis-Análisis (Dubberly, Evenson, & Robinson, Interactions New York, 2008)

2 Antecedentes de Pensamiento Visual

En toda representación visual —abstracta o no— construida desde un afán comunicativo yace una fuerza unificadora que permite al lector experimentar aquella imagen como un todo. La experiencia de un total, en el ámbito de la imagen, constituye el acto del estar ante, esencia misma de la visualización. Si bien este estar ante no constituye una prerrogativa para la condición de total (bien se puede estar ante un fragmento), la noción de totalidad es fundamental para la comprensión; el distingo que otorga el nombre otorga la fuerza requerida para asir determinado concepto.

Esta misma fuerza unificadora es la que está presente en la poesía japonesa del haikú, forma literaria altamente simple y marcadamente nominal, y que se constituye como antecedente paradigmático de la capacidad de integración de una imagen poética. Sus palabras, esencialmente sustantivas y, por tanto, cargadas visualmente, cuidan su encadenación, su sonoridad, su ritmo y su cadencia. Cuando todos estos elementos están enlazados con maestría, el resultado corresponde a la cristalización de un nuevo total; del mismo modo en que notas marcadamente distintas y características logran construir un acorde musical, algo notoriamente superior a la suma individual de las partes.

Japonés	*Romanización*	*Castellano*
古池や 蛙飛込む 水の音	*furuike ya* *kawazu tobikomu* *mizu no oto*	**El viejo estanque** **salta una rana** **ruido de aguas**

Haikú, Matsuo Bashô (松尾芭蕉)

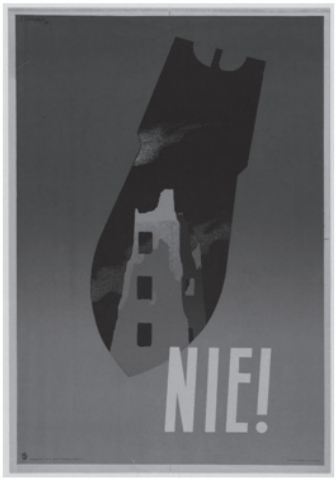
Esta forma poética aparentemente simple tiene cifrada en su cohesión interna su potencia poética: las partes componentes son imágenes nítidas y definidas pero eclécticas entre sí. Es la fuerza disonante que se logra hilvanar o conectar armando una imagen que detona en el lector el sentido de la imagen poética. La proeza del poeta consiste en forjar la relación de las partes yuxtapuestas por medio de conectivas declaradas o tácitas (implícitas). Es lo que llamamos una configuración.

Esta misma noción de "configuración cohesionada de partes aparentemente disonantes" está presente también en el movimiento gráfico polaco de la postguerra que instauró la llamada imagen conceptual. La "imagen conceptual" recibe este nombre porque en la segunda mitad del siglo XX "la transmisión de imágenes informativas no solamente era narrativa, sino de ideas y conceptos."

Al igual que el haikú, el ejemplo de Tadeuz Trepkowski (Figura 2a) reúne, con una potencia inaudita, tres elementos naturalmente inconexos. La invención y construcción del discurso gráfico consta de dos partes: la elección de los elementos significativos (i) y la gramática visual que los configura (ii) definiendo relaciones dramáticas expresiva y construyendo un discurso retórico entre ellos: “no a la guerra que trae la destrucción”.

En el afiche (Fig. 2a), se ve claramente la existencia de una configuración conceptual detrás de la construcción gráfica. Cabe destacar la hábil elección de los elementos constituyentes, altamente icónicos y reconocibles, y con una carga emocional grabada en la memoria cultural de una Polonia destruida por la guerra. Si hacemos el ejercicio de descifrar los conceptos llevándolos a la configuración de un mapa conceptual acotado a los elementos constituyentes de la imagen (Fig. 2b) podremos distinguir las relaciones textuales del discurso. Por medio de este ejercicio queda claro que la potencia del discurso visual radica en la interpretación visual de las conectivas.

Si bien en esta época no estaba definida la idea de mapa conceptual, es visible que el ser humano realiza un proceso análogo para comprender y presentar las conceptos y argumentos.



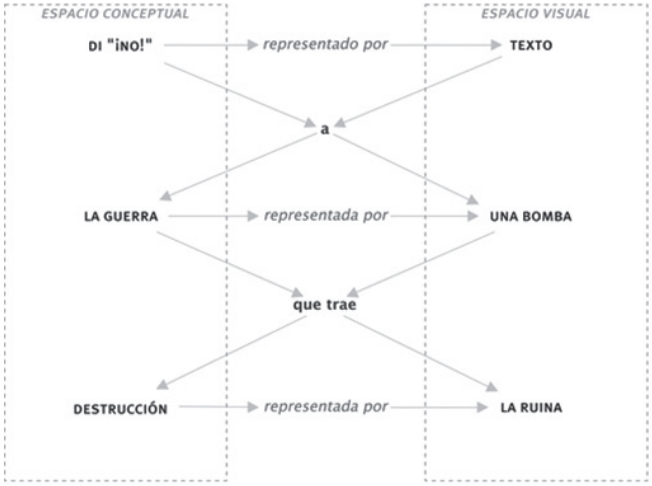


Figura 2a. Afiche, Tadeuz Trep¬kowski, "Nie!" (No!) 1952
Figura 2b. Análisis del discurso (Fig 1a)

3 El vínculo entre el Mapa, Imagen y Modelo

3.1 El Mapa como Imagen Mental

Al definir como mapa conceptual el proceso inherente del ser humano de construir un discurso visual y plantearlo como herramienta de aprendizaje, se permite visibilizar el espacio conceptual que vive en la intangibilidad, creando una imagen mental que hace accesible el conocimiento de éste espacio. Un claro ejemplo de la relación de imagen-concepto es la que ocurre cuando se enseña a niños a construir relaciones conceptuales, esto es dicho por Novak, cuando señala a los profesores pautas para la enseñanza por medio de mapas conceptuales, insistiendo en que el niño debe crear o asociar el concepto con una imagen mental por medio del entendimiento del mapa.

"Pregunte a los niños si ven algún tipo de imagen mental cuando pronuncia unas cuantas palabra desconocidas para ellos. (En un diccionario se pueden encontrar palabras cortas que probablemente sean desconocidas para los niños; por ejemplo, la palabra “concepto”) [p 10].

"Presente la palabra concepto y explique que un concepto es la palabra que empleamos para designar cierta “imagen” de un objeto o de un acontecimiento. Repase algunas de las palabras que se escribieron en la pizarra y pregunte a los niños si todas ellas son conceptos; pregunte si todas ellas hacen que aparezca una imagen en la mente." Novak, J. D., & Gowin, D. B. (1984).

Esto muestra la necesidad que tiene el ser humano de llevar los conceptos al plano visual para poder entenderlos y apropiarse de ellos. Esto a la larga exige una complejidad mayor al lenguaje que va más allá de recursos gráficos como color, tipografía, sino que exige una jerarquía estructural coherente e inherente a una abstracción de conceptos. Esta abstracción es de una manera visual para construir modelos que identifiquen patrones y puntos de conexión, y así que estos produzcan estímulos sensoriales para lograr la percepción y el aprendizaje.

3.2 La Imagen Conceptual como Construcción de Conocimiento

... La percepción consiste en la formulación de “conceptos perceptuales”...el proceso visual...parece llenar las condiciones de la formulación de conceptos... El uso de la palabra “concepto” no debe hacer pensar de ninguna manera que el acto de percibir sea una operación intelectual. Debe pensarse que los procesos descriptivos tienen lugar en el aparato visual. La percepción logra al nivel de los sentidos, lo que en el reino de la razón se llama entendimiento. (Arnheim & Fernández-Campoamor, 2002).

[1] Si bien existen ejemplos notables con anterioridad, como el collage surrealista, no los incluimos porque queremos centramos en expresiones que construyen un discurso retórico claramente intencionado.

Hasta ahora, cabe distinguir dos aproximaciones al espacio visual: desde el mapa y desde la imagen. El mapa se va tejiendo a medida que declara sus términos y establece las conexiones que otorgan la coherencia y la continuidad al texto. La construcción del mapa avanza en encadenaciones inductivas y deductivas donde la figura total será una resultante muchas veces inesperada y siempre inconclusa; es decir, desde la parte se llega al total. La imagen, por otro lado, opera de modo inverso: para poder leerla primero accedemos a un total configurado. Luego vamos penetrando en ella, con la mirada cayendo en nuevos detalles y distinguiendo nuevas partes componentes que completan y definen.

En el mapa, las leyes de encadenación —o sintaxis— están claramente definidas. Su posibilidad expresiva radica en la elección de los términos y categorías, y en la definición de sus relaciones y jerarquías. Aquí la lectura se mueve en el plano de los nodos y las conectivas. En la imagen, en cambio, se construyen en distintos planos consecutivos que definen una sintaxis gráfica abierta. Su lectura puede ser más evocativa y emocional, como también puede oscilar entre la parte y el total. Todo esto para interpretar de forma válida la experiencia ”por medio de la forma organizada” pues ”ver es comprender”.(Arnheim & Fernández-Campoamor, 2002) .

Es precisamente en el diálogo de estas dos miradas: entre la mirada consistente y conexa del mapa que cuida las relaciones de contigüidad encadenada y la mirada de la imagen que compone relaciones gráficas que cuidan y resuenan con el total que definimos el espacio del modelo visual.

4 Modelamiento Visual del Espacio

Según la RAE, un modelo es un “esquema teórico” de un “sistema o de una realidad compleja”,que se elabora para “facilitar su comprensión y el estudio de su comportamiento.” El espacio visual al que comparece esta totalidad, en el caso de un modelo, es abordado simultáneamente como mapa conceptual y como imagen. Los elementos componentes del modelo se definen desde un criterio análogo al empleado en la construcción de un mapa conceptual, pero incorpora articulaciones y relaciones gráficas no necesariamente textuales que articulan el todo en un plano puramente visual que conforma una representación —esquemática, alegórica o simbólica— del fenómeno representado en el modelo. Estos modelos permiten comprender en profundidad fenómenos intangibles como procesos, experiencias, servicios y sistemas; con una estructura conceptual y una articulación visual hacia la conformación de un total configurado. El sentido consiste en hacer visible un argumento no importando la codificación o sintaxis que este tenga a nivel interno, es decir, pasamos de la abstracción unívoca hipertextual del mapa a una abstracción multívoca o difusa del espacio de la significación visual.

Dentro de la programación, el proceso de abstracción se da de manera unívoca, es decir, es el mismo algoritmo de la máquina el que valida o no la realidad del modelo propuesto; si operamos sobre una abstracción errónea, el programa simplemente no funciona. Este tipo de abstracción se ha vuelto transversal a varias disciplinas y el diseño no se ha marginado de esto; muchos proyectos en el ámbito del diseño de interacción requieren competencias en el campo de la abstracción unívoca (o programación), como lo hemos llamado. Dentro de este ámbito está ampliamente difundido y aceptado el concepto de programación orientada a objetos, es decir, una aproximación conceptual análoga al mundo físico donde las partes componentes abstractas del programa obedecen a contrapartes físicas o conceptuales. Esta aproximación permite construir representaciones esquemáticas de los programas.

El proyecto Kaleido[2] (Chang A 2009, Figura 3) propone formalizar el espacio visual entre la intencionalidad del diseñador y la transcripción al código. Este espacio se denomina como una perspectiva, y permite estructurar un modelo mental del algoritmo transitando de ida y vuelta entre conceptualización y código, de modo que el modelo pasa a formar parte del proceso creativo. Cabe destacar la coexistencia de modos de abstracción: la unívoca presente en el código y la abierta o multívoca presente en el modelo. El modelo, en este caso, es de un carácter marcadamente personal y funciona como andamiaje cognitivo intermedio.

[2] Extensión del proyecto Processing (http://www.processing.org), entorno de desarrollo de programación para diseñadores y artistas.

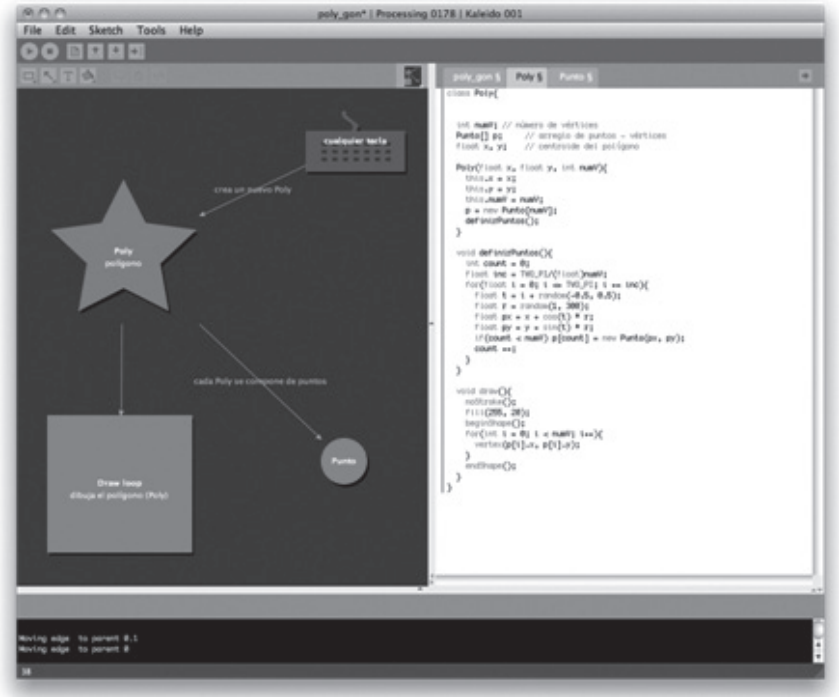


Figure 3. Kaleido (Chang A, 2009), Extension del Entorno de Desarrollo Processing (Fry B, Reas C, 2003)

4.1 Caso de Diseño: Modelos de Experiencia

A través de la comprensión esquemática de una experiencia podremos reconocer sus partes y puntos significativos dentro de ella. Por definición, una experiencia es personal y de difícil comunicación sin que pierda atributos esenciales. En el Diseño de Servicios la comprensión de la experiencia de los usuarios constituye el objeto mismo del estudio y del posterior trabajo propositivo. Para operar sobre este campo se construye un "modelo de experiencia genérico" agregando diversas experiencias individuales y traslapando patrones y aspectos comunes.

En este caso, retratamos la experiencia del paciente en el servicio de salud pública en Chile. Para encontrar los patrones dentro del servicio construimos preliminarmente un mapa conceptual (Figura 4) que define los elementos y conceptos a considerar en el modelo. Este mapa permite limpiar, delimitar y dejar sólo lo necesario para mostrar esa experiencia, pero luego construimos esas relaciones con la ayuda de imágenes, jerarquías visuales y proporcionalidades. Este modelo se construye progresivamente a través de un proceso iterativo que busca validarse ante los actores involucrados dentro del servicio (Figura 5a). Este modelo validado permite definir una estructura visual de base que nos permite operar sobre ella para comunicar, por ejemplo, las problemáticas y áreas críticas de la experiencia. El modelo se transforma así en un objeto fronterizo para el diálogo y el análisis crítico (Figura 5b).

Volviendo al proceso de diseño (Figura 1) luego de construir "el modelo de lo que es" y entender el ámbito en que la experiencia se lleva a cabo podemos concluir en un modelo de "lo que debe ser", como ejercicio de orden propositivo final o de base para la ejecución de prototipos.

Si bien existen ejemplos notables con anterioridad, como el collage surrealista, no los incluimos porque queremos centramos en expresiones que construyen un discurso retórico claramente intencionado.

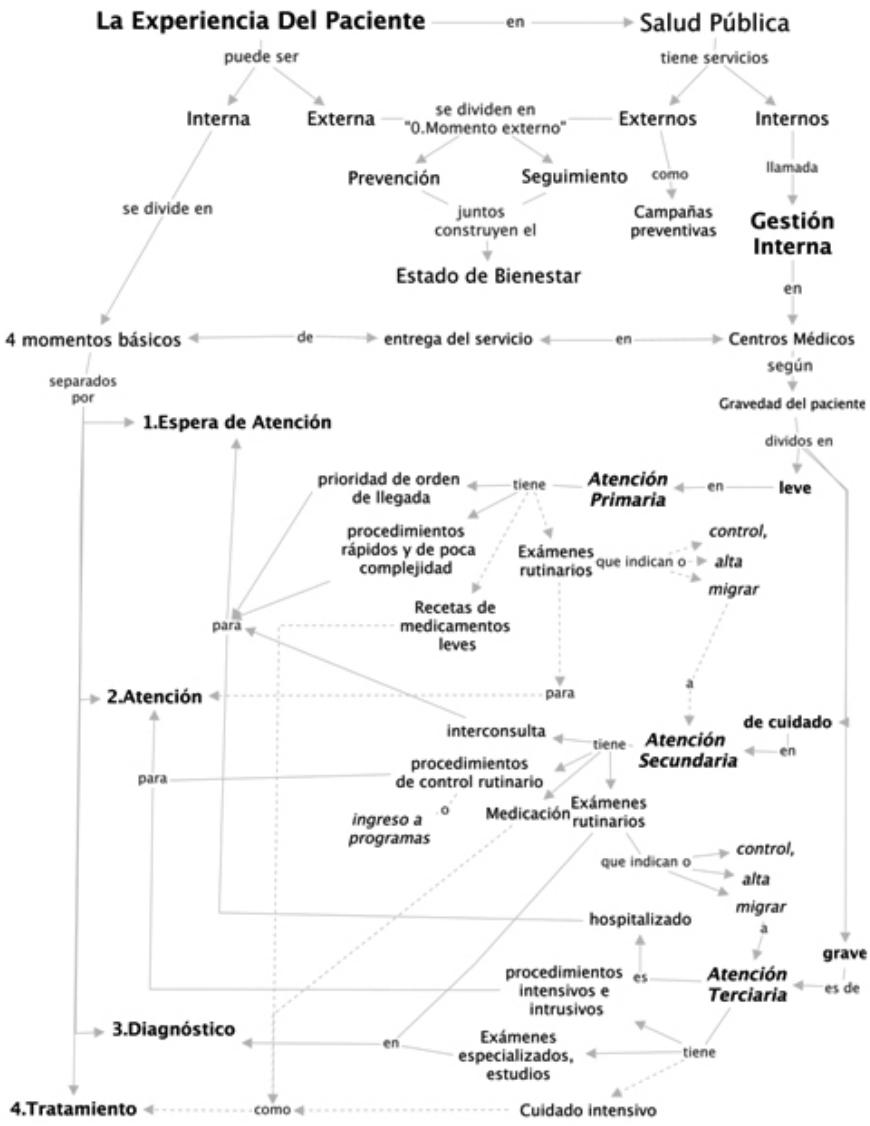


Figura 4. Mapa Conceptual que describe la experiencia del Paciente en la Salud Pública. (Sepúlveda D. 2010)

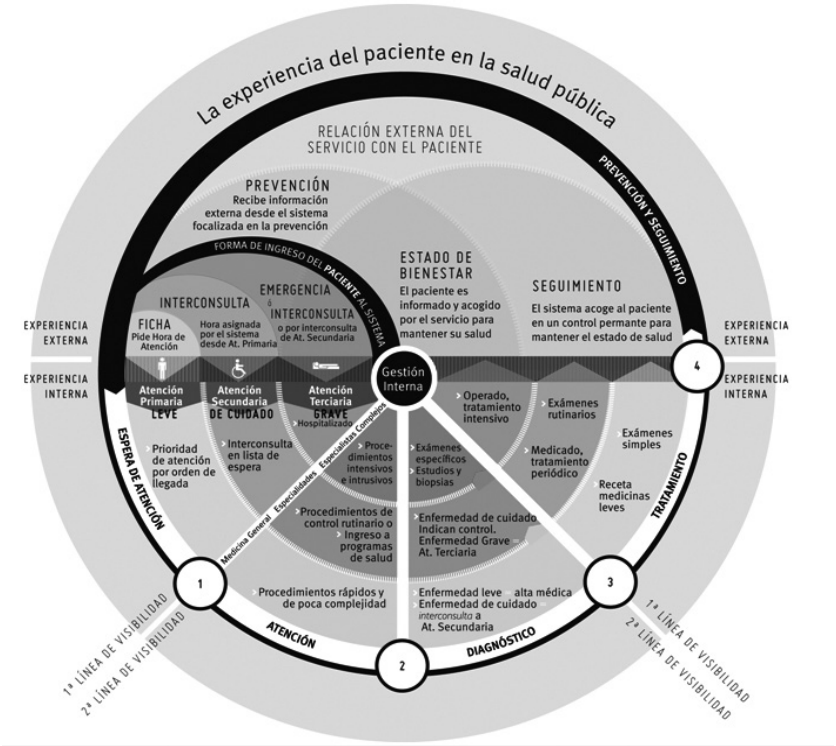


Figura 5a. Modelo Genérico de la Experiencia del Paciente en la Salud Pública (Sepúlveda D. 2010)

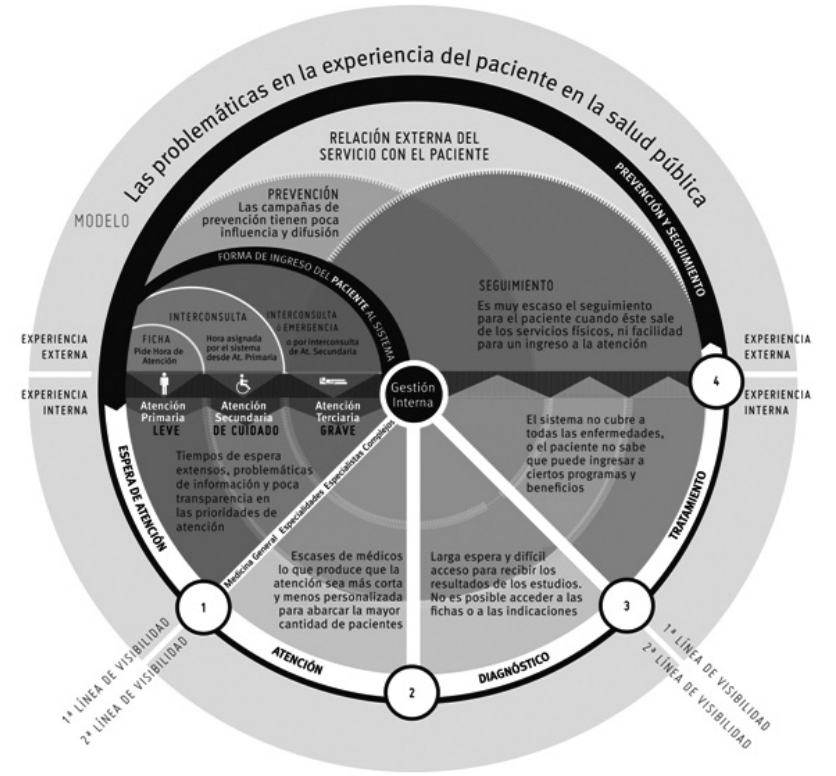


Figura 5b. Modelo de las Problemáticas de la Experiencia del Paciente en la Salud Pública (Sepúlveda D. 2010)

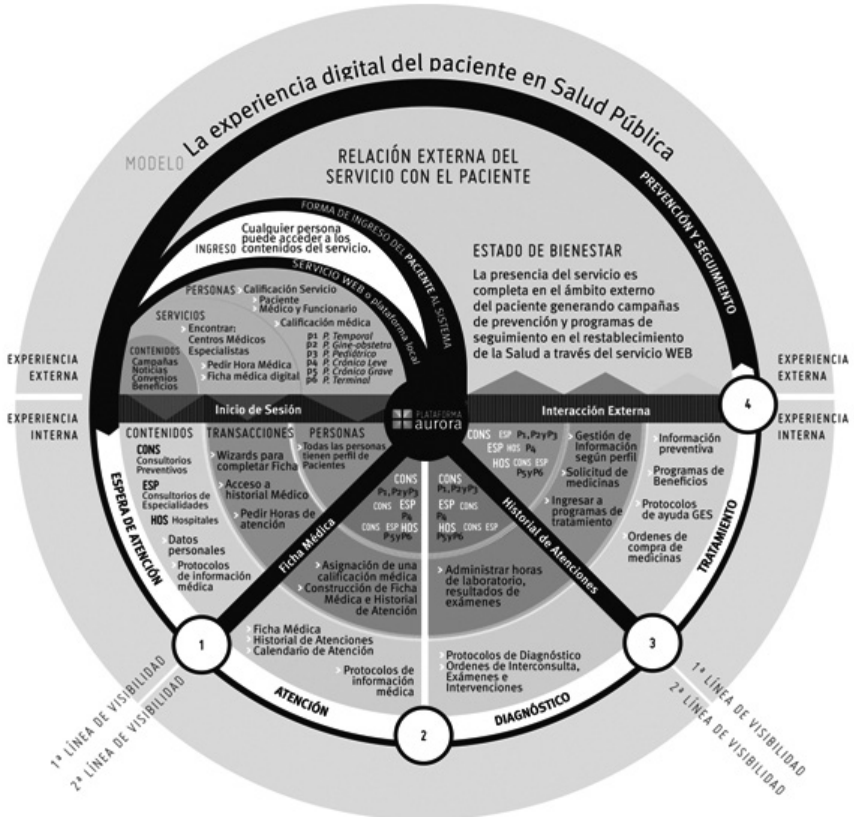


Figura 5c. Modelo de las Cómo debería ser la Experiencia del Paciente en la Salud Pública. (Sepúlveda D. 2010)

5 Conclusiones

La sintaxis detrás de los mapas conceptuales, dada su simpleza y versatilidad, es altamente eficiente para tejer relaciones y extender redes conexas de términos relacionados, es decir, ofrece las leyes para la nodificación visual del lenguaje apelando a nuestra capacidad de distinguir, abstraer y conectar. Su posterior vinculación y configuración se da en conexiones discretas. Los modelos visuales, representaciones utilizadas como herramientas en Diseño y herederos directos de los mapas conceptuales, extienden la sintaxis textual de conectivas verbales "seriales y bilaterales" a relaciones visualmente más elaboradas que buscan una estructuración coherente con el total (una gestalt). Estos modelos, que paradójicamente siendo más ambiguos, por carecer de un sistema de codificación convencional, resultan finalmente más efectivos para la construcción de argumentos y para comunicar ideas complejas ya que los elementos unitarios conforman una coherencia total.

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Concept Maps: Making Learning Meaningful
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EL PAPEL DE LOS MAPAS CONCEPTUALES EN LA ORGANIZACIÓN DEL PENSAMIENTO DE LOS ESTUDIANTES

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Resumen. En este trabajo se presenta una experiencia de aula realizada con estudiantes universitarios de un programa de Licenciatura en Pedagogía Infantil. El problema del que parte esta experiencia es la reiterada opinión de los docentes sobre las dificultades de los alumnos para organizar sus ideas, relacionar conceptos y sintetizar los textos a los que se enfrentan cotidianamente. Frente a esta problemática el autor consideró oportuno aplicar los mapas conceptuales como una estrategia pedagógica que contribuyera a mejorar el desempeño de los estudiantes en los aspectos inicialmente mencionados. Para valorar el progreso en la estructuración de los mapas se utilizó la taxonomía topológica desarrollada por Cañas y et al (2006) y una rúbrica para evaluar el desempeño cognitivo. La experiencia se realizó durante un semestre académico y a los resultados promedio se aplicó el estadístico t de studens para comparar la media obtenida por los estudiantes en la primera y segunda parte del semestre. La experiencia resultó positiva en cuanto que los estudiantes mejoraron sustancialmente la organización de su pensamiento. Se encontró, igualmente, una correlación positiva entre la estructura de los mapas conceptuales construidos por los estudiantes y su desempeño cognitivo.

1 Introducción

Novak (1998b) ha descrito la técnica y el origen de los mapas conceptuales de distinta manera. En una de ellas menciona que la técnica surge como una herramienta y un método permitiendo "representar las estructuras cognitivas y sus cambios en los niños" en estudio (p.14). La herramienta y el método son dos niveles funcionales del mapa conceptual cuya distinción es analítica dado que en el proceso de investigación las funciones que ha adquirido el mapa conceptual son resultado del proceso mismo de desarrollo de la herramienta y de su adaptación a nuevas situaciones de investigación.

Novak y Gowin (1988) hacen referencia a otras formas de representación, que al igual que los mapas conceptuales, poseen la característica de representar significados, estos son: los diagramas de flujo, las redes semánticas, los mapas mentales etc. La función que los autores atribuyen a los mapas conceptuales es la de servir como herramientas para la representación (Novak, 1998).

Para Novak y Gowin (1988): "Los mapas conceptuales tienen por objeto representar relaciones significativas entre conceptos en forma de proposiciones". Para Novak (1998): "Los mapas conceptuales desempeñarán una función clave como herramienta para representar los conocimientos del aprendiz y la estructura del conocimiento en cualquier terreno". Y "Los mapas conceptuales son herramientas de representación de los marcos proposicionales y de significado o que se poseen para un concepto o grupo de conceptos". No cabe duda de que para los autores mencionados los mapas conceptuales constituyen por excelencia una herramienta de representación del conocimiento.

El fundamento teórico de los mapas conceptuales (Novak, 1988), es que la estructura cognitiva está organizada jerárquicamente a través de redes de proposiciones. Novak y Gowin (1988) definen los mapas conceptuales como "recursos esquemáticos para representar un conjunto de significados conceptuales incluidos en una estructura de proposiciones". Según Novak, las proposiciones se estructuran formando una jerarquía de inclusión. En el ejercicio de la construcción de un mapa conceptual, el sujeto va estableciendo tipos de relación. El tipo de enlace explica el tipo de significancia de la relación, y el lugar en que se ubica el concepto en la red de relaciones, define el tipo de relación como: subordinada derivativa, subordinada correlativa, supraordinada o combinatoria. Además los enlaces pueden ser, directos, recíprocos, generar enlaces cruzados, contribuyendo con el "grado" de significancia de la relación. Existen conceptos relevantes de los cuales se desprenden gran cantidad de enlaces, y conceptos a los cuales llegan gran cantidad de enlaces desde otro concepto, también los hay como conectores entre diversas partes del mapa.

Desde esta perspectiva el conocimiento puede ser comprendido como un proceso de construcción de representaciones y su comunicación es realizada por medio de distintos medios representacionales (Olson, 1999). Po eso el mapa conceptual se constituye en un sistema de representación que puede ser utilizado para comunicar y representar conocimiento y que su estructura proposicional, permite darle una estructura que lo dotan de sentido y lo configuran como texto. La forma en que se lee (interpreta) el mapa conceptual puede cambiar, tal como sucedió con el texto escrito (Olson, 1999), la escritura de los propios mapas conceptuales dando lugar a nuevas representaciones, estructuras y funciones y relaciones con otros textos.

Desde nuestro punto de vista, es justamente en el aula de clases en donde adquiere un sentido especial esta herramienta, pues contribuye a transformar el modo en que los alumnos pueden aprender. Esto es consecuente con la idea de utilizar los mapas como lo que son: "herramientas". El objetivo debe estar siempre en los procesos cognitivos que se desdoblan con estas herramientas. Los mapas conceptuales son herramientas que permiten visualizar lo que un estudiante conoce sobre un tema; pero más aún, permiten ver el proceso de aprendizaje y cómo el estudiante logra construir el conocimiento. Es esta la principal razón por la que se escogieron como eje central de la experiencia de aula que se relata en este artículo. Las debilidades presentadas por los estudiantes para organizar, relacionar y jerarquizar sus ideas creemos que puede ser superada utilizando estratégicamente esta herramienta.

La perspectiva desde la que se utilizan los mapas en esta experiencia se centra en la búsqueda constante del docente y del estudiante. En un proceso de análisis y reflexión que les permita a los estudiantes construir conocimiento y aprender.

De otra parte, las dificultades de comprensión lectora de los estudiantes frente a los textos expositivos propios de las disciplinas que estudian, constituyen otra preocupación investigativa fundamental en la que los mapas conceptuales aportan de una manera extraordinaria y que no se puede separar del proceso de construcción de conocimiento en cuanto que tal proceso tiene como base la comprensión de los textos.

Ahora bien, si la comprensión de cualquier texto es un objetivo fundamental en el proceso educativo, la de los textos expositivos tiene, si cabe, más relevancia, ya que es la forma en la que habitualmente se presentan los textos escolares. Estos textos describen relaciones lógicas entre acontecimientos y objetos en orden a informar, explicar o persuadir (Brewer, cit. por Mayor y Pinillos, 1992). A diferencia de los textos narrativos, los textos expositivos plantean cierta dificultad y obligan al lector a aplicar todos los recursos cognitivos disponibles, convirtiendo su lectura en una tarea compleja.

En el abordaje de un texto expositivo intervienen procesos psicológicos que están encaminados a extraer las relaciones entre los elementos descritos en el contenido del texto, formando una representación de la estructura lógica del mismo. Esos procesos transforman el texto en una representación semántica que supone una abstracción mediante la que se selecciona y se sintetiza la información, una elaboración, en la que entran en juego los conocimientos previos del sujeto que lee y, la adopción de una representación organizada con la que el contenido del texto es almacenado en la memoria.

El orden de los conceptos es de tipo jerárquico, es decir, los conceptos más generales ocupan niveles superiores en el plano del mapa conceptual mientras que los más particulares se encuentran en el nivel más bajo. La jerarquía depende también de la trama completa en la cual se relacionan los conceptos, es por esta razón que el nivel que ocupan en el plano puede variar así como su jerarquía, pues esta propiedad siempre está en relación al conjunto de conceptos que conforman el mapa conceptual.

La representación de la jerarquía es fundamental para comprender la organización del conocimiento que un alumno tiene sobre los temas y a partir de esto reconocer concepciones erróneas (Novak y Musonda, 1991). Esta información sirve al maestro para determinar la estrategia de ayuda al alumno para el aprendizaje de los conceptos. Novak (1991) sostiene que el conocimiento es construido por los humanos mediante conceptos y sus relaciones y la teoría de Ausubel como el marco explicativo de los procesos de asimilación del conocimiento (Novak y Musonda, 1991, p.129), de ahí la importancia de reconocer el proceso de diferenciación conceptual que permite la construcción y aprendizaje de la jerarquía de los conceptos.

Son claras entonces, las ventajas que los mapas conceptuales tienen para la extracción y organización de las ideas y conceptos centrales de un texto. Pero la valoración de estos beneficios no cuenta aún con métodos que se aproximen de manera objetiva a lo que cualitativamente los estudiantes logran con la aplicación de esta herramienta. Por esa razón se ha asumido la taxonomía topológica propuesta por Cañas et al (2006) para valorar los resultados obtenidos en la experiencia de aula que se presenta en este trabajo, como complemento a la valoración semántica de los mapas construidos por los estudiantes. Es oportuno aclarar, siguiendo a los autores, que se asume la taxonomía no como la manera "correcta" de evaluar los mapas ni como un sistema de calificación. Se asume, en este caso, como un sistema complementario de valoración adaptado al contexto donde se llevó a cabo la experiencia.

Además, en la experiencia que el autor ha tenido con la aplicación de mapas conceptuales ha encontrado situaciones muy similares a las que se han encontrado en el proyecto Conéctate de Panamá (Cañas et al 2006), algunas de las cuales son también una comprobación de la dificultad natural de traducir al lenguaje escrito (lineal) un proceso cognitivo que es estructural.

La topología propuesta por Cañas et al (2006) "consta de 7 niveles (del 0 al 6), en los cuales se valoran cinco criterios: a) el uso de conceptos en vez de trozos de texto, b) el establecimiento de relaciones entre conceptos, c) el grado de ramificación, d) la profundidad jerárquica, y e) la presencia de enlaces cruzados" (p. 3).

El primer criterio de la taxonomía es de carácter semántico en tanto que la presencia de frases en un mapa conceptual suele ser indicativa de estructuras de conocimiento memorísticas. De acuerdo con este primer criterio, un mapa en el que predominan trozos de texto recibe la valoración de cero (0), independientemente de su complejidad o de la presencia de cualquier otro elemento estructural.

El segundo criterio valora la presencia o ausencia de palabras de enlace, sin tener en cuenta su certeza semántica o la manera como se haya realizado (a mano o con una herramienta informática).

El tercer criterio es el grado de ramificación del mapa. Este criterio está relacionado con el número de puntos de ramificación, es decir, el número de líneas de conexión que surgen de un nodo, un concepto o una frase de enlace. Según los autores, este criterio no se refiere al número de ramas que emergen de un nodo dado, sino al número de nodos que presentan más de una rama.

El cuarto criterio es la profundidad jerárquica. Se determina contando el número de enlaces que hay entre el concepto raíz y el concepto más alejado del concepto raíz o del concepto más inclusor.

El último criterio evalúa la presencia de enlaces cruzados. Un enlace cruzado es aquél que une dos o más conceptos que se encuentran en diferentes sectores dentro del mapa sea en un mismo nivel de jerarquía o atravesando diferentes niveles de la misma, pero donde ninguno de los cuales es el concepto raíz.

2 Problema y objetivos de investigación

A partir de la revisión de literatura realizada antes de iniciar la experiencia se formuló la siguiente pregunta de investigación: ¿Qué evolución tiene la organización del pensamiento en estudiantes universitarias cuando trabajan con mapas conceptuales como estrategia pedagógica?. A su vez los objetivos específicos del proyecto fueron los siguientes: a) Determinar los cambios en la capacidad de los estudiantes para extraer, relacionar y jerarquizar los conceptos principales de un texto, b) Determinar el desempeño cognitivo de los estudiantes sobre los conceptos estudiados c) Determinar si existe correlación entre la estructura de los mapas construidos por los estudiantes y el desempeño cognitivo de los mismos.

3 Sujetos y contexto educativo

La investigación se realizó con estudiantes de Licenciatura en Pedagogía Infantil de una universidad privada que cursaban la asignatura "Constructivismo" en el tercer semestre del programa. La experiencia se llevó a cabo con tres grupos en semestres consecutivos, pero aquí se presentan los resultados del último semestre de la experiencia. La

edad promedio de las estudiantes era de 18 años y la mayoría pertenecían al estrato social medio. Se trabajó con 31 estudiantes de género femenino.

4 Procedimiento

El procedimiento utilizado fue el mismo que se venía perfeccionando en los dos primeros semestres de la experiencia, así como el material de apoyo utilizado para trabajar los conceptos básicos de la asignatura. Los mapas conceptuales fue la estrategia utilizada en el 80% de las clases. Por trabajarse con una muestra intencional de estudiantes matriculadas en el grupo natural del semestre, no se pudieron controlar variables como el estrato social o la edad de los participantes.

La dinámica empleada durante el desarrollo de la asignatura fue la siguiente:

En el proceso de inducción a la asignatura, desde el primer día se les explicaba a los estudiantes cuál iba a ser la estrategia que se iba a utilizar, los requisitos de la misma, el compromiso que exigía por parte del profesor y de los estudiantes, el proceso metodológico de implementación y la forma de evaluación.

Las primeras dos semanas se utilizaban para entrenar a los estudiantes en la utilización de la estrategia a partir de pequeños fragmentos del tema de la asignatura. Durante estas dos primeras semanas toda la actividad se realizaba con papel y lápiz. Los primeros ejercicios de aplicación se realizaban con pequeños párrafos inicialmente señalados por el profesor y luego escogidos libremente por los estudiantes.

Una vez que los estudiantes demostraban mayor dominio del espacio para estructurar los mapas y mayor claridad conceptual sobre los mismos, se organizaban sesiones en un aula de informática donde se les enseñaba a manejar Cmap Tools. Los pequeños mapas que habían construido en las dos primeras semanas, constituían el material para ejercitarse en el dominio de la herramienta.

Cada estudiante debía llevar un portafolio con los mapas conceptuales, incluidos los borradores, es decir, no se podían tirar los intentos iniciales de construcción porque el propósito pedagógico de los portafolios era que cada estudiante pudiera analizar la secuencia de su progreso en la elaboración de los mapas conceptuales.

Después que cada estudiante en particular realizaba el mapa que correspondía a determinada lectura o fragmento de lectura, se realizaba una sesión donde cada estudiante socializaba su trabajo y la sesión concluía con mapas construidos colaborativamente en grupos de tres o cuatro personas. Al terminar una unidad de la signatura los estudiantes debían construir un mapa general de la misma donde se integraban sus mapas particulares y los mapas construidos colaborativamente. En esos mapas debían señalar con colores distintos los aportes personales que podían realizar a la estructura del mapa.

Dos de las cuatro evaluaciones de la asignatura se realizaban por medio de entrevistas sobre sus mapas conceptuales, incluyendo el examen final y parte de las otras dos incluían varias técnicas relacionadas con los mapas conceptuales como completar mapas incompletos.

El examen final se realizaba con base en un mapa integrador de todos los temas tratados, en donde se integraban los demás mapas elaborados durante el semestre, y que terminaba siendo un gran mapa multicolor que algunos para su presentación no lo hacían por medio de Cmap en la pantalla del computador sino en grandes cartulinas que llevaban al aula dada la cantidad de conceptos incorporados.

5 Resultados

En primera instancia se presentan los resultados arrojados por la prueba t de studens con relación a la apropiación y manejo de los mapas conceptuales y luego los resultados de la rúbrica que se aplicó para evaluar el dominio conceptual de los estudiantes sobre el tema de la asignatura.

La t de studens se utilizó para determinar si se dieron diferencias significativas en el desempeño de los estudiantes al terminar la primera parte del semestre en relación con el desempeño obtenido por éstos en la segunda parte del semestre. Como se trataba de medir dos veces a un mismo grupo, se escogió la t para muestras relacionadas, utilizando para el tratamiento el SPSS versión 11.5.

Como se observa en la Tabla 1, la media del desempeño de los estudiantes en la primera parte del semestre es menor que la obtenida en la segunda parte. Se observa igualmente que es mayor la dispersión en la primera parte que en la segunda, por lo tanto, podría decirse que en la medida en que avanzaba el semestre el grupo se hacia más homogéneo en cuanto al desempeño con los mapas conceptuales.

En la Tabla 2 se observa que la correlación (0,32) de las dos medidas del grupo no es significativa para $p<0,05$, es decir, no existe una relación lineal entre los dos momentos y por lo tanto no se puede afirmar de que quienes puntuaron alto o bajo en la primera parte del semestre hayan puntuado también alto o bajo en la segunda parte del semestre.

De acuerdo con la información que muestra la Tabla 3, la media del desempeño del grupo en la segunda parte del semestre (4,37) es significativamente mayor que la obtenida por el grupo en la primera parte (3,16) dado que la t obtenida (12,4) es mayor que la esperada a un nivel $p < 0,001$. Estos resultados permiten inferir que los estudiantes lograron avanzar significativamente en la identificación de los conceptos principales de los textos estudiados, establecer relaciones adecuadas entre ellos y organizar los conceptos de manera jerárquica.

		Media	N	Desviación típ.	Error típ. de la media
Par 1	RESULT1	3,16	31	,517	,093
	RESULT2	4,37	31	,402	,072

Tabla 1. Estadísticos de muestras relacionadas

		N	Correlación	Sig.
Par 1	RESULT1 y RESULT2	31	,322	,078

Tabla 2. Correlación de muestras relacionadas

	Diferencias relacionadas					t	gl	Sig. (bilateral)
				95% Intervalo de confianza para la diferencia				
	Media	Desviación típ.	Error típ. de la media	Inferior	Superior			
Par 1 RESULT1 - RESUL	-1,21	,544	,098	-1,41	-1,01	-12,416	30	,000

Tabla 3. Prueba de muestras relacionadas

Para evaluar el dominio conceptual alcanzado por los estudiantes se diseñó una rúbrica. Esta rúbrica fue aplicada para evaluar de manera integral la asignatura. Los estudiantes debían sustentar un mapa general integrando los mapas que se habían construido durante el semestre. Las categorías que se evaluaron fueron: dominio de conceptos y terminología, conocimientos de las relaciones entre conceptos, seguridad y habilidad para sustentar los mapas y metacognición. Cada categoría se evaluó con la escala de: insuficiente, suficiente, bueno y muy bueno. En la Figura 1 se presenta el desempeño de los estudiantes en esta rúbrica.

De acuerdo con esta gráfica, el 64% de los estudiantes logró extraer los conceptos principales de los textos estudiados y argumentar bien o muy bien la selección y organización de los mismos en un mapa conceptual. De igual manera, el 41% de los estudiantes lograron relacionar bien o muy bien los conceptos seleccionados y argumentar dichas relaciones. El 55% demostró seguridad para sustentar sus mapas y el 45% utilizó bien o muy bien su capacidad para analizar y evaluar sus procesos de pensamiento y para reconocer las ventajas e inconvenientes de trabajar con mapas conceptuales.

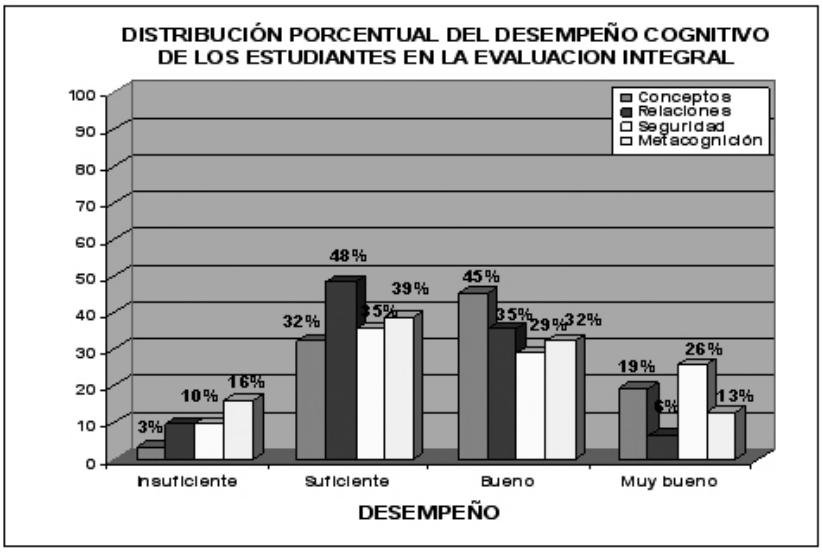


Figura 1. Desempeño cognitivo de los estudiantes

Para determinar si existía correlación entre la estructura de los mapas construidos por los estudiantes y el desempeño cognitivo de los mismos, se utilizó un análisis de regresión y una correlación lineal por medio del software SPSS versión 11.5 en español. La correlación lineal se utilizó para determinar la fuerza de las relaciones entre las dos variables y la regresión para determinar la naturaleza de las relaciones entre ellas.

Los resultados de la correlación se muestran en la Tabla 4. De acuerdo con esta tabla, la correlación es de 0,618, la cual es altamente significativa para una p>0,01, lo que indica que entre las dos variables existe una alta correlación.

		TAXONOM	EVAINTEG
TAXONOM	Correlación de Pearson	1	,618**
	Sig. (bilateral)	.	,000
	N	31	31
EVAINTEG	Correlación de Pearson	,618**	1
	Sig. (bilateral)	,000	.
	N	31	31

**. La correlación es significativa al nivel 0,01 (bilateral).

Tabla 4. Correlaciones

Los resultados de la regresión que se presentan en las Tablas 5 y 6 indican en primera instancia, que el valor obtenido de F(17,892) es significativo a un nivel de p<0,001 (Tabla 5) lo que permite inferir que ambas variables están linealmente relacionadas. En segunda instancia, a partir de los resultados de la tabla "Coeficientes" (Tabla 6) se puede concluir que la pendiente poblacional de la recta de regresión (coeficiente Beta) es significativamente distinta de cero, lo cual nos permite concluir que la relación lineal entre las variables es altamente significativa (p<0,001).

Modelo		Suma de cuadrados	gl	Media cuadrática	F	Sig.
1	Regresión	1,613	1	1,613	17,892	,000[a]
	Residual	2,615	29	,090		
	Total	4,228	30			

a. Variables predictoras: (Constante), EVAINTEG

b. Variable dependiente: TAXONOM

Tabla 5. Anova

Modelo		Coeficientes no estandarizados		Coeficientes estandarizados	t	Sig.
		B	Error típ.	Beta		
1	(Constante)	2,774	,241		11,504	,000
	EVAINTEG	,284	,067	,618	4,230	,000

a. Variable dependiente: TAXONOM

Tabla 6. Coeficientes

6 Conclusiones

De acuerdo con los resultados obtenidos en el desarrollo de la asignatura, es evidente que los estudiantes lograron un significativo progreso en la capacidad para estructurar los mapas conceptuales, es decir, para extraer los conceptos principales de un texto, relacionarlos y organizarlos jerárquicamente. La evolución de sus logros se observa con claridad en el mejoramiento progresivo que se marca en los niveles de estructuración de los mapas conceptuales que iban construyendo en la medida que avanzaba el semestre. Las diferencias significativas que se dieron entre las medias correspondientes a la primera y segunda parte del semestre así lo confirman.

Dado que la valoración de la taxonomía era fundamentalmente estructural, era importante establecer si a esa evolución estructural de los mapas correspondía también una apropiación cognitiva sobre los contenidos que se habían tratado durante el semestre. Las pruebas estadísticas utilizadas demuestran que, en este caso, existe una correlación lineal positiva que indica que quienes puntuaron alto en la estructuración de mapas también lo hicieron en el nivel de apropiación de los conceptos estudiados.

En lo que concierne a la utilización de la taxonomía topológica vale la pena mencionar que para este caso no fue necesario utilizar el nivel 0 de la escala dado que ninguno de los mapas elaborado por los estudiantes presentaba esas características. Si bien en los primeros mapas se presentaba la utilización de explicaciones nunca predominaron frente a los conceptos. Si bien podían faltar algunas palabras de enlace nunca alcanzaba a ser un número significativo. La explicación de esta circunstancia puede estar en que tratándose de un curso centrado en la construcción de mapas, desde el principio se enfatizó y se supervisó el cumplimiento de las características antes mencionadas y por ello fueron pocas las dificultades que se presentaron desde el punto de vista estructural. Por esa razón también el nivel 1 fue de poca frecuencia. Esta circunstancia obligó a que el criterio simple de presencia o ausencia de conectores tuviera que remplazarse por un criterio más semántico pues en efecto no todas las palabras de enlace contribuían a construir proposiciones conceptuales y a veces eran artículos o preposiciones de frases trasladadas al mapa.

Otra dificultad que se encontró en la práctica, fue lo concerniente al número de ramificaciones y al número de relaciones cruzadas. En el primer caso había que tener en cuenta la extensión de los textos trabajados pues no todos se prestaban para construir el número de ramificaciones esperadas; y en el segundo porque fue el punto de mayor complejidad según opinión de los estudiantes, por esa razón la puntuación máxima no tuvo mayor frecuencia entre los estudiantes. En los mapas integrados, por cubrir más temas la escala funcionó mejor en estos últimos aspectos. Pero en la experiencia que el autor ha tenido con docentes de distintas áreas que han manifestado saber elaborar mapas conceptuales la escala refleja mejor los inconvenientes y las ideas erróneas que tienen sobre esta estrategia. Se seguirá investigando sobre esta propuesta. En el anexo Nº 1 se presenta un mapa con calificación de nivel 4 en la taxonomía y en el anexo Nº 2 un mapa con calificación de nivel 6.

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ENHANCING COLLABORATIVE PROBLEM SOLVING IN DISTANCE EDUCATION COURSES USING WEB-BASED CONCEPT MAPPING

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Abstract. The purpose of this study is to investigate the use of web-based concept maps as a communications and problem-solving tool in an online graduate level course. The study used an exploratory-descriptive research design that applied a qualitative methods approach in order to explore how concept maps foster collaborative problem-solving activities in an online learning environment. Three of the five groups participating in the study effectively used concept mapping, which they combined with other communication strategies such as eliciting group suggestions, asking questions, and brainstorming ideas, to reach consensus and solve the CBR project required. These results indicate that concept maps are a practical and effective strategy to help distance learners communicate and collaborate in order to solve problems in online courses.

1 Introduction

Higher education is increasingly expanding its services through the implementation of online distance education. The distance learners of today are able to engage in collaborative problem solving, threaded discussions, and peer tutoring through asynchronous and synchronous distance learning environments. Gunawardena and McIsaac (2004) affirm that one of the recent trends in distance education research focuses on understanding pedagogical issues in the CMC (computer mediated communication) environment, and especially on collaborative learning in CMC. They emphasize the need for further research in this area because of the recent growing interest in facilitating collaborative learning in online environments.

From a constructivist and socio-constructivist viewpoint (see Bruner, 1966; Vygotsky, 1978; Leontiev, 1978), students should be provided with strategies and skills that foster collaborative learning, as well as with environments that allow them to share their cognition in a social context. Both the instructor and individual learners in the group can offer strategies that facilitate this social interaction and shared cognition (Resnick, 1991). Concept mapping is one of these strategies.

For the purpose of this study, we define a "concept" as a generalized idea of a thing or class of things, designated by a word or symbol that represents a unit of knowledge or meaning. A concept map is defined as a graphical representation that includes concepts, usually enclosed in circles or boxes; links, which are represented by lines or arcs ending in an arrow head and which show the directionality of the relationship between concepts; and words within each link which create a meaningful statement relating the two connected concepts. One or more concepts with a single link to other concepts, descriptions, or characteristics is referred to as a proposition if together these form a meaningful statement (Novak & Cañas, 2008). A concept that is not linked to anything else is referred to as an "independent concept."

In online distance education, interactive concept maps can become useful tools for students in groups to enhance the co-construction of knowledge, which leads to effective learning. Coffey & Cañas (2000) note that online courses that implement mapping techniques as a part of the course design may use them in activities such as brainstorming by individuals or groups, collective decision making, designing projects, organizing papers, and formulating research plans. Another possible application for concept mapping would be as a knowledge integration tool. Constructivist theory argues that new knowledge should be integrated into existing structures in order to be meaningful and be remembered (Jonassen & Wang, 1993).

The purpose of this study, therefore, is to understand the use of web-based concept maps as a communications and problem-solving tool in an online distance education graduate level course. This study will examine students' collaborative efforts to solve a case-based reasoning (CBR) problem during a semester-long period in order to explore how concept maps foster collaborative problem-solving activities in an online learning environment.

2 Collaborative Concept Maps as a Tool to Foster Students' Problem Solving

Following many years of research measuring the effectiveness of concept maps in a standard instructional setting, as cited in Novak & Cañas (2006), the literature now reflects a new research trend that focuses on exploring the use of web-based concept mapping techniques in the learning process and their effects in collaborative learning environments (Kremer, 1996; Plotnick, 1997; Stoyanova & Kommers, 2002; Keller, Tergan, & Coffey, 2006). Plotnick (1997) was one of the first to suggest that concept mapping might be an effective way to enhance the problem-solving phases involved in generating alternative solutions and options in a collaborative group effort. A concept map may, of course, be created by a single individual to organize and clarify his ideas. Alternatively, when a group collaborates to produce a concept map, the map represents the combined ideas of the group. In either case, concept mapping can be used as a communicative tool for people to discuss concepts and their relationships. In a group, this tool allows them to reach agreement on common terms and a common structure to use as a basis for further action (Plotnick, 1997). Such an agreement process developed within the group is referred to as the "collaborative construction of knowledge."

Researchers have examined a variety of aspects of concept mapping. Gaines and Shaw (1995), for example, have described the application of groupware concept mapping tools designed to support collaboration in dispersed learning communities. Their data shows that consensual maps are usually developed through negotiation. Gaines and Shaw have also observed that students working in collaborative groups usually divide responsibility by expertise or by preferences. They note that these groups end up producing a great deal of additional material in the form of networks of linked maps and associated resources.

Other research supports the idea that learning styles can play an important role in groups working on concept maps. This study on the effects of learning styles on group interaction (Papanikolaou, Gouli, & Grigoriadou, 2006) focused on the role that individual differences among group members played in collaborative concept mapping tasks. For example, a group would benefit if it included both visual and verbal learners, rather than just one or the other type of learner. The overall results of this study indicate a positive relationship between the inclusion of participants with a variety of learning styles in a group and the group's success with collaborative concept mapping tasks.

Fischer, Bruhn, and Mandl (2002) performed a study showing that one way of increasing the quality of discourse among members of collaborative learning groups is to provide visualization tools. The researchers found that concept maps as visualization tools supported the construction of knowledge by encouraging the learning partners to focus on and apply new concepts to task-relevant content.

Research by Keller, Tergan, and Coffey (2006) explored the use of a specific kind of awareness tool to improve the collaborative learning process. Groups used this KIA-Tool ("knowledge & information awareness" tool) to make their members aware of the knowledge and corresponding underlying information of the other collaborators, which increased the members' problem solving skills.

Stoyanova and Kommers (2002) investigated the effectiveness of concept mapping for computer-supported collaborative problem solving. The main assumptions underlying this research are that shared cognition is crucial to cognitive construction and reconstruction of knowledge, and that concept mapping is an effective tool for mediating computer-mediated collaboration.

3 Questions Addressed by This Study

This study addresses two research questions:

Research question 1: Is there a relationship between the propositions selected collaboratively by a group in constructing a concept map and the propositions stated in the solutions to the CBR problem as evident in the paper they completed?

The second research question expands on the first.

Research question 2: How did the generation of a collaborative concept map help to solve the CBR problem?

4 Methods

We will first discuss the design of the online course which was used for this research study, and then the research procedures for our study. An online graduate course on the Theory and Practice of Distance Learning offered by a Southwestern University in the United States was designed using the WisCom design model (Gunawardena, Ortegano-Layne, Carabajal, Frechette, Lindemann, & Jennings; 2006), which is based on socio-constructivist theory. The WisCom design model emphasizes collaborative problem solving achieved through knowledge innovation, mentoring, and learner support, in a community-of-practice learning environment.

Five groups of students were each required to collaboratively solve an instructional problem in distance education using a CBR format. They were asked to apply the distance education principles learned in the online course to develop a distance education system that incorporated solutions to the problem they were given. Of the five groups, four groups contained three students and one group consisted of two students. These five groups are referred to as A, B, C, D, and E. Each group was required as a final course assignment to submit a concept map that reflected the group´s solutions to the problem and a paper describing their proposed solutions. The groups were evaluated and graded based upon these concept maps and papers.

Students were encouraged to use Cmap Tools software as a collaborative learning tool to generate their concept maps. Students were also asked to save all of their communications while generating the concept maps and the paper. These communications were saved in a discussion thread in WebCT intentionally set up for this purpose, and also in the Cmap software´s discussion thread and annotations. Each group generated one paper and one concept map which presented their graphical representation of the solutions to the problem.

4.1 Participants

The subjects for this study were fourteen graduate students: 10 females and four males. Of these students, 10 were Anglo-American, 3 Native American, and 1 Hispanic. The average age was 40. None of the students had generated a concept map before the study. Only a few had prior knowledge of concept maps as a strategy for organizing ideas.

4.1.1 Procedures

All of the students were trained in concept mapping techniques using Cmap Tools v.3 software (2003), focusing on specific collaboration features such as adding discussion threads to each concept as well as using annotation features to support the knowledge construction process. The training took place during the orientation session conducted face-to-face at the beginning of the semester. The software was selected because it is open-source and network-enabled, allowing the users to build and collaborate during the construction of concept maps with colleagues anywhere on the network. The participants were not only able to share and navigate through each others' concept maps, but the program also allowed them to integrate resources like documents, pdf files, and videos.

4.1.2. Data Collection

Data from this study came from five sources: 1) the concept map that each group generated to solve the problem; 2) the paper that each group wrote explaining their solutions; 3) the discussion threads in WebCT and Cmap where each group discussed the solutions of the problem; 4) the annotations in Cmap, which showed the groups' thinking processes; and 5) the survey on collaborative problem solving that was administered after the groups had created their concept maps.

The purpose of the survey was to determine which communication strategies students used during the problem solving task and to obtain information about their experiences while using collaborative web-based concept maps to solve the problem. Students were also asked to suggest the appropriateness of using these strategies for future online courses. The survey consisted of eight questions: two were Likert-scale and six were open-ended. The first Likert-scale question asked which strategies the group used to come to consensus on solving the problem. The second Likert-scale question asked each group to rank order the usefulness of the communication strategies they had employed in the problem solving activity. The open-ended questions asked them to describe: 1) their preferences among the communication strategies they used; 2) how the concept map facilitated interaction among members of the group; 3) how the online map generated by the group helped in the problem solving activity; 4) the advantages and disadvantages of using concept maps for promoting collaborative learning in distance education; 5) how the concept map helped the group to negotiate ideas to arrive at a consensus on what to include in the solutions to the problem; and 6) any additional suggestions or recommendations for using concept maps in future online courses. Two experts determined the construct validity of this survey.

4.1.3. Analysis

To address the first research question, all CBR papers and their respective concept maps were analyzed and compared in order to identify to what degree propositions stated in the maps helped students to write the CBR paper. First, using content analysis, researchers looked for concepts and propositions in the paper. Each of these was labeled with a number. All concepts and propositions were then summarized by the researchers at the end of each group paper. Second, a similar process was conducted with each concept map, by counting and summarizing the number of nodes or concepts, the number of propositions, the number of links, and the number of linked words. After all of the concepts and propositions had been identified and labeled, researchers made comparisons between the maps and the papers. For example, if the concept presented in the map matched any concept mentioned in the paper, that concept was counted as a single concept presented in both places. The same process was followed using propositions.

As shown in Table 1, several relationships were established between concepts stated in the map and in the paper. For instance, researchers compared the number of concepts that were stated in the map but not stated in the paper and vice versa. We expected that when a greater number of concepts and propositions appeared in both the map and the paper, this strong relationship would indicate a high probability that generating a concept map had effectively supported the collaborative problem solving process.

To answer the second research question, the researchers analyzed and compared several sources of data: a) computer transcripts generated by each group; b) each group's concept map; c) each group's CBR paper; and d) the online survey soliciting students' opinions on the use of concept maps as a collaborative communication tool to solve a common problem. ATLASti v.4.2 was used to analyze the computer transcripts obtained from discussion threads and annotations generated in the Cmap public server; the data from discussion threads generated in WebCT related to the CBR project; the CBR paper; and the open-ended questions from the survey. The Likert-scale questions were analyzed by examining computer frequencies and percentages, and the results were graphically represented using Microsoft Excel 2000. All the data obtained and analyzed was triangulated. A comparison of these results allowed the researchers to evaluate the degree to which each group attempted to use collaborative learning strategies for solving the problem and to what extent the generation of a collaborative concept map helped them to solve the CBR project.

5 Results and Discussion

The groups in the study had been given the freedom to start solving the CBR problem either through the generation of a concept map or by directly writing the paper. For those groups who decided to use the concept map as a starting point to solve the problem (3 out of 5 groups), there was a close relationship between the concepts and propositions generated in the concept map and those presented in the CBR paper. This implies that concept maps can serve as a foundation for solving problems in a distance education setting by assisting the students in identifying concepts, propositions, and the relationships among them. Table 1 breaks down the numbers of concepts and propositions used by each group.

Groups	Number of propositions in both map & paper	Number of concepts in paper but not in map	Number of concepts in map but not in paper	Total number of concepts/ propositions in paper	Total number of propositions in map
Group A	35	22	11	57	39
Group B	23	34	41	57	23
Group C	35	25	12	60	35
Group D	8	59	2	67	8
Group E	16	23	13	39	16
All Groups	117	163	79	280	121

Table 1. Number of concepts and propositions used by the groups on maps and CBR papers

As the table shows, Group A generated a total of 39 propositions of which 35 were found in both their paper and map, a high correlation. However, despite this strong correlation, 22 out of the 57 concepts in the paper were not present in the map. At the same time, there were 11 independent concepts stated in the map that were not referred to in the paper. We repeated this map-paper comparison process with the five groups. For those groups that had generated a collaborative concept map before writing their paper, we found a high correlation between the concepts presented in the map and the paper.

The correlations between maps and papers given in Table 1 will not address 1) how the collaborative concept map allowed the group to arrive at solutions for the CBR project; 2) which negotiation strategies were used by the group; and 3) how students arrived at a consensus in order to solve the problem. Therefore, research question number 2 examined those areas using a triangulation method. The results for both research questions for each group are summarized in the following descriptions of the groups' problem solving processes and their evaluations of the use of concept mapping.

Group A used the concept mapping technique as a brainstorming tool; they agreed that the tool was useful to begin solving the problem, but worked on the problem using a cooperative rather than collaborative strategy. They used the concept map to support their online discussion via e-mail, but divided their task once they made the decision about which components to include in their problem. About the value of a concept map, they state: " …it helped us to show gaps in our development and training needs." They also said that "concept maps posed a challenging way to think about problem solving." They agreed that the map helped them visualize the components to be included in the solutions presented in the paper and that it also helped with the creation of more concepts that were not present in the map.

Group B collaboratively generated a total of 23 propositions on the map, all of which were used to support their solutions in the paper. We also identified 34 independent concepts given in their paper which were not found in their map, as well as 41 concepts in the map that were not discussed in the paper (see Table 1). The high number of shared concepts makes us believe that the concept mapping process was useful to the group. They noted that their communication strategies were discussion threads, annotations, chat, and email; they felt these methods enabled them to make more efficient use of their time. One of the group members said that using the concept map allowed him/her to visualize good ideas and was useful for clarifying ideas. Another member said, "We could see quickly if someone had misunderstood what we were trying to say. It helped to keep us on track." The third member added, "Using maps was the main key for this assignment. If it is clear for all, then it will be easy to see the whole in a meaningful way." They all agreed that the generation of concept maps was a source for discussion, as well as a tool for providing a meaningful way of organizing concepts. One person said, "The generation of concept maps was only one strategy that helped to work collaboratively…the use of communicative tools such as discussion threads, annotations, and email was very important for the solution of our CBR project". This group used concept maps as a collaborative tool at the beginning, but once the main concept map was developed, they divided their tasks based on the components stated in the map, using e-mail communication and the CBR communication space located in the WebCT server to collaborate.

Group C generated three maps to represent the distance education system proposed to solve the CBR problem. A total of 35 propositions were found in both the map and the paper. Of the 60 concepts/propositions discussed in

the paper, 25 were not represented on the concept map. Of the total of 85 concepts in the map, which includes those appearing in propositions, only 12 concepts were not discussed in the paper. This strong relationship between the maps generated and the solutions given in the paper supports the conclusion that creating the concept maps was very helpful to this group's completion of the project. The group reported that the communication strategies they used were those allowed by Cmap Tool and their discussion space in WebCT. Two of the group members agreed that concept maps helped them as tools for organizing and brainstorming. However, they reported that it was difficult as a group to agree on ideas to include in their paper or on solutions. One person regretted having to use concept maps, saying that maps did not help the group to solve the problem. This group noted that the level of complexity is higher when a concept map is generated incorporating others' ideas and levels of expertise, making the collaborative work effort a far more complex task.

Group D was comprised of three members, two of whom reported that they were experienced with computers. These same members expressed no confidence in using concept maps to generate solutions to the CBR project. However, since the creation of a concept map was part of the assignment requirement, they generated two maps. They used the first as a graphic representation of organizations within a distance education system, but this map did not contain any propositions. Each independent concept in the map is mentioned in their paper. The second concept map contained eight propositions, all of which were referred to in the CBR paper. Both maps contained a very low number of nodes, link words, and propositions. This group of students generated the greatest number of concepts in the paper, a total of 67 (see Table 1), but the correlation between maps and paper was quite weak. Group D was the only group whose members interacted solely through email communication and phone calls. The main reason they used email was because this system allowed them to speed up the communication process. Based on the analysis of their survey responses, this group did not work using collaborative learning strategies. They divided their responsibilities, and said "our primary strategy was to communicate through email, because for us that was an easy way to fill in sections of the paper related to areas of expertise. It worked well for us." Other members said they chose email "because it was easier to share versions of the paper and combine our contributions, ask each other questions, etc.". With regard to concept maps, they asserted that they all disliked the idea of using concept maps to solve their CBR problem. They argued that concept maps were not the best option for them because maps did not correspond to the way they think and solve problems; they preferred to communicate verbally, not visually. They argued that concept maps might be good for visualizing ideas and concepts but did not work for knowledge construction. Although this group did not use concept maps as a collaborative learning tool to solve problems, two members did mention some advantages. They said that concept maps are good for visual learners, allowing them to see the way in which others are thinking, and that this strategy would be helpful for expressing concepts across language and cultural barriers. We can conclude from this group's responses that students in future online courses need to be trained not only in the use of concept mapping and related software, but also in strategies to promote collaborative group learning.

Group E generated two concept maps. The first map contained a total of 21 concepts but had no link words, nor any evidence of connectors to form propositions. Of those 21 concepts, only 8 were present in the CBR paper. The second concept map contained 16 propositions, all which were present in the paper; however, this number is low by comparison to the number of shared propositions in Groups A, B, and C. In addition, the paper written by this group was weak; it presented the fewest number of solutions to the problem. This group used email as part of their communication strategy. When asked about concept maps as a strategy to facilitate group interaction, one of the three group members pointed out that the map served as a visual aid. The second member said, "I think it painted a clearer picture than just explaining verbally." However, the third member disagreed, saying the group had more interaction via email than by using the concept map. Although this group took longer than others to understand how to use the concept map as a collaborative tool, they agreed that the map helped them visualize CBR solutions. The group member who regretted using the Cmap Tool said, "Maps would work better if you are very clear on what you are building. Otherwise I think it would be very confusing." However, based on another member´s opinion, it seemed the group did learn how to use the map as a collaborative problem solving strategy by the end of the project. This member said, "I think it is helpful to use a concept map to structure all our thoughts together, but some group members did not think it was important, so there was little participation as a group effort in the concept map process until the end of the project." The same member affirmed in the survey that " I personally enjoyed making and using the concept map. I would like to suggest promoting the use of concept map as a strategy to learn and teach at the graduate level." The second member pointed out that it is important to have an entire session to train students in the use of concept maps in a collaborative learning environment before starting to learn about the course content.

From our analysis of the online survey, we found that four out of five groups had created concept maps to support their problem solving process and felt that this strategy had helped them to solve the CBR project. Only group D started the problem solving process by writing the paper first and then generating a map based on their paper. The rest of the groups used several strategies to reach consensus among the members, including concept mapping, asking for group suggestions, using questions, and brainstorming ideas.

The analyses of online discussions generated in WebCT and Cmap showed that the concept maps and the related discussions helped the groups solve the CBR project. There was enough evidence from groups A, B, and C to demonstrate high-to-moderate correlations between the propositions generated in their maps and later referred to in their CBR papers. Data triangulation showed that groups A, B, and C were using the concept maps to support or guide their problem solving process. In response to the survey, 50% of the students said that the most useful strategy for them during the CBR problem was creating a concept map, in combination with other communication strategies such as eliciting suggestions, asking questions, and brainstorming.

In the survey, groups A, B, C, and E mentioned that using a concept map for solving problems helped them with three main tasks: 1) to visualize all the important elements to be included in the problem; 2) to visualize gaps and suggest possible solutions; 3) to be able to see the entire problem at once. All three benefits allowed them to identify the appropriate strategies to generate more ideas within their own group and devise solutions for the problem.

Table 2 shows the advantages and disadvantages of using concept maps to solve a collaborative problem for distance education which students identified in the surveys that they completed at the end of the project.

Advantages	Disadvantages
Cmap Tool software can be used to: • Synthesize social construction of knowledge. • Preserve knowledge obtained from online environments. • Organize complex information. • Represent complex ideas. • Brainstorm ideas to be included in a problem-solving task. • Communicate ideas. • Negotiate ideas. • Reach consensus. • Visualize the whole. • Visualize different alternatives to solve a problem. • Visualize gaps or deficiencies in the problem context. • Facilitate collaborative learning and social construction of knowledge.	**Cmap Tool software requires that:** • Students have strong computer skills. • Computer hardware be able to support the software and interact with the server. • Students be trained in concept maps and collaborative use of the software. • Students be given sufficient time to learn-practice using concept maps. • Individual differences among group members be addressed. Otherwise, these could create obstacles in the learning process—e.g., visual students could react positively while verbal learners could refuse to use concept maps.

Table 2. Advantages and disadvantages of using Cmap in web-based instruction.

6 Summary

These research results suggest that web-based concept maps could be used collaboratively in online distance education graduate courses. When the collaborating groups generated concept maps to solve the problem prior to writing a paper giving their solutions, the propositions in the concept map correlated highly with those in the paper. This high correlation answers our first research question and leads us to believe that creating the concept map facilitated the problem solving process. The fact that three of the five groups in the study included even more concepts in their papers

than in their concept maps seems to indicate that making these maps helped them write the paper, encouraging further discussion and concept generation in the process.

In answer to our second research question, the majority of the groups pointed out that generating a collaborative concept map was a time-consuming task. The students' main explanation for this was that it was difficult for them to build their own ideas upon someone else´s ideas in an online concept map. Doing this required many discussions to reach agreement, negatively impacting the time it took to complete the task.

According to our analysis of the survey, groups combined diverse communication strategies to reach consensus and solve the CBR project. These strategies included concept mapping, eliciting group suggestions, asking questions, and brainstorming. Groups also combined diverse communication channels during the problem solving process, such as concept maps, discussion threads, annotations, and email messages.

Our results suggest that concept maps are a practical and effective strategy to help distance learners communicate and collaborate in order to solve problems in online courses. However, in order to promote online collaborative learning using web-based concept mapping, groups need to be provided with specific training on how to use concept maps as a communication and collaboration tool.

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ENSEÑAR CREATIVAMENTE: LOS MAPAS CONCEPTUALES Y LA UVE DEL CONOCIMIENTO ¿PUEDEN FOMENTAR LA CREATIVIDAD?

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Resumen. El objetivo del trabajo consiste en profundizar principalmente el estudio de la aplicación durante el proceso de enseñanza aprendizaje, de las herramientas metacognitivas, en particular, los mapas conceptuales y la UVE del conocimiento o heurística (también denominada de Gowin, en honor a su creador), lo cual permitiría fomentar habilidades creativas en el campo de las ciencias exactas y naturales. Para corroborar esta afirmación, se analizó una experiencia educacional de profesores universitarios que completaron su formación docente con una maestría o una especialización en la enseñanza de ciencias exactas y naturales, que utilizaron durante su práctica docente las mencionadas herramientas. Existe numerosa bibliografía que se refiere a distintas formas de encarar la enseñanza teniendo en cuento a las distintas perspectivas del docente y del alumno, como por ejemplo "enseñar creativamente", "enseñar para la creatividad", "docencia creativa", "aprendizaje creativo" etc. En todos estos casos, se reconoce una fuerte interacción entre los sujetos involucrados en el proceso de enseñanza-aprendizaje. En el caso que aquí presentamos, consideramos promisorios los resultados de la encuesta, a favor de una enseñanza competente como un medio o metodología, mediante la cual ambos sujetos participantes interactúan y colaboran para lograr una práctica áulica que asegure un aprendizaje creativo.

1 Introducción

1.1. La enseñanza competente y la creatividad

En el caso que aquí presentamos, consideramos la enseñanza competente como un medio o metodología, mediante la cual ambos sujetos participantes, (docentes y estudiantes) colaboran para lograr una práctica áulica que asegure un aprendizaje efectivo, el cual, unido al criterio teórico del aprendizaje significativo, asegure el cumplimiento de las condiciones necesarias para que el estudiante adquiera las competencias propias de los individuos creativos.

Investigaciones sobre formación del profesorado concluyen que el soporte emocional, formar parte de una red de trabajo con los estudiantes, la retroalimentación externa y la oportunidad de continuar formándose a nivel de posgrado, representan los principales elementos de enriquecimiento para la enseñanza competente con el consiguiente logro de individuos creativos.

Otro aspecto a considerar es que el conocimiento humano trae aparejada la reflexión acerca de lo que se sabe o se cree saber. El proceso de enseñanza involucra mucho más que la mera transmisión de los saberes socialmente válidos. También implica reflexiones acerca de qué son esos saberes, en qué contexto se han establecido, qué validez o limitaciones poseen, e incluso cómo se los rechaza. Compromete siempre cierta reflexión con relación a aquello que se sabe. El docente que aspire a una enseñanza competente, deberá reflexionar acerca de las cuestiones de aprendizaje en el contexto de su relación con aspectos metodológicos que conduzcan a lograr estudiantes que puedan ser creativos a través de la adquisición de aprendizajes significativos.

Analizando el concepto de creatividad desde el punto de vista ausubeliano (Ausubel, D., Novak, J.D., & Hanesian, H.; 1978) y su relación con al aprendizaje significativo, podemos establecer las condiciones mínimas que se requieren para lograr estudiantes creativos:

•Estructuras de conocimiento bien organizadas.
•El impulso emocional necesario para buscar conexiones entre diferentes dominios de conocimientos.
•Transformar estructuras de conocimiento conceptualmente opacas a estructuras conceptualmente transparentes.
•Integrar constructivamente el pensar, sentir y actuar, a través de la experiencia.

Estas aspiraciones se pueden lograr considerando: primero que nada, un verdadero cambio mental, desde la opción convencional a la constructivista. En segundo lugar mediante los criterios emergentes de una teoría comprensible sobre el aprendizaje humano (aprendizaje significativo) y, finalmente, mediante la utilización de herramientas de enseñanza-aprendizaje que respondan a los criterios de la metacognición (herramientas metacognitivas); en este caso nos ocupamos específicamente, de los mapas conceptuales y la UVE de Gowin, que según nuestro criterio resulta ser de inestimable ayuda para los fines propuestos.

1.2. La uve heurística de Gowin

El uso del diagrama UVE propuesto por Gowin (ibid.) permite imaginar aproximadamente una docena de los elementos epistémicos más relevantes, que componen un cuerpo de conocimientos, ocupando diferentes espacios de la estructura intelectual.

Es importante señalar que los elementos epistémicos están relacionados entre ellos y que si estas relaciones no están bien establecidas en la estructura intelectual, el diagrama reflejará, posiblemente, concepciones espontáneas. En tal caso, las elaboraciones futuras (en niveles superiores de la UVE) resultarán, probablemente, defectuosas. Esta propiedad del diagrama UVE de reflejar las concepciones espontáneas, es lo que lo hace particularmente útil para aplicarlo a la educación, ya que permite visualizar en forma simple las proposiciones que necesitan ser re-elaboradas.

La UVE ayuda a "desempaquetar" en forma imaginaria, un determinado cuerpo de conocimientos y a analizar cada uno de sus distintos componentes epistemológicos, para luego reestructurarlos y reconstruirlos desde una nueva perspectiva, lo que permite obtener un cuerpo de conocimientos más amplio y evolucionado con el consecuente aumento de las aptitudes creativas. Esta representación utilizada en un área de conocimientos determinada recibe el nombre de la UVE del conocimiento, tal como se grafica en la Figura 1.

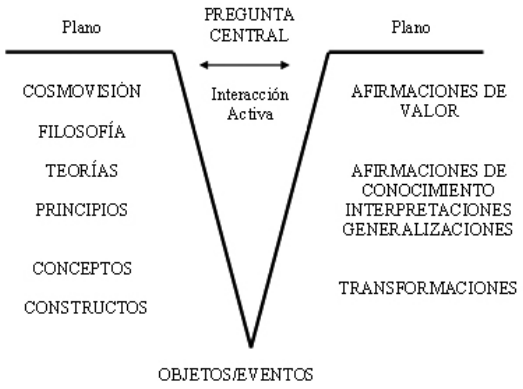


Figura 1. La UVE heurística como una representación de la estructura del conocimiento: una docena de elementos epistémicos. (Novak & Gowin, 1988)

1.3. Los mapas conceptuales

Puede afirmarse que los "mapas conceptuales", introducidos por Dr. J.D. Novak en la Cornell University, USA (Novak, J.D. & Gowin, D.B.; 1986), constituyen una ayuda para que el estudiante y el docente vean más claramente el significado del material a aprender.

Los mapas conceptuales fueron desarrollados durante el transcurso de las investigaciones educativas realizadas por Novak y su equipo, mientras se buscaba entender los cambios producidos en las estructuras de conocimiento de los estudiantes durante el aprendizaje de las ciencias. El programa de investigación usaba como marco teórico, la teoría del aprendizaje significativo de D. Ausubel (Ibid.). La idea fundamental de esa teoría es que el aprendizaje tiene lugar mediante la asimilación de nuevos conceptos y proposiciones por las estructuras conceptuales y proposicionales ya existentes en la mente del que aprende.

Los mapas conceptuales desarrollados en el programa de investigación antes mencionado, resultaron ser herramientas útiles que permiten organizar y representar cuerpos de conocimientos. Ellos incluyen conceptos, generalmente encerrados en un rectángulo o círculo, y relaciones entre conceptos o proposiciones, indicadas por una línea de conexión entre dos conceptos. Las palabras sobre la línea especifican las relaciones entre los dos conceptos. Las proposiciones son oraciones que contienen dos o más conceptos conectados por palabras de enlace que le permiten formar un significado. Algunas veces las proposiciones se denominan "unidades semánticas" o "unidad de significado".

Elaborar mapas conceptuales es un método que facilita un aprendizaje repleto de significado. Requiere que se realicen decisiones esenciales acerca de: (1) la importancia de las ideas, (2) cómo estas ideas se relacionan unas con otras y (3) cómo estas ideas se relacionan con los conocimientos previos.

El estudiante verá así facilitada su tarea de relacionar conceptos basados en nueva información con el conocimiento previamente adquirido.

Dado la amplia difusión que actualmente ha tenido esta herramienta metacognitiva, no abundaremos en más detalles sobre la misma, solamente agregamos dos ejemplos de su aplicación que se muestran en las figuras 2 y 3.

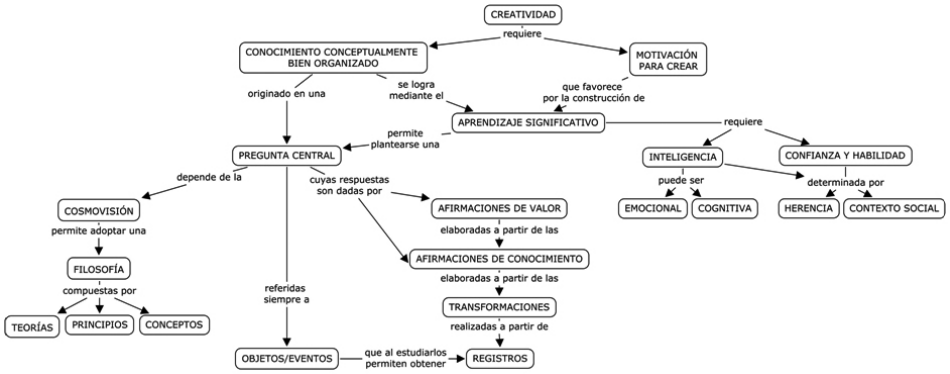


Figura 2. Mapa conceptual mostrando relaciones de la UVE con la creatividad

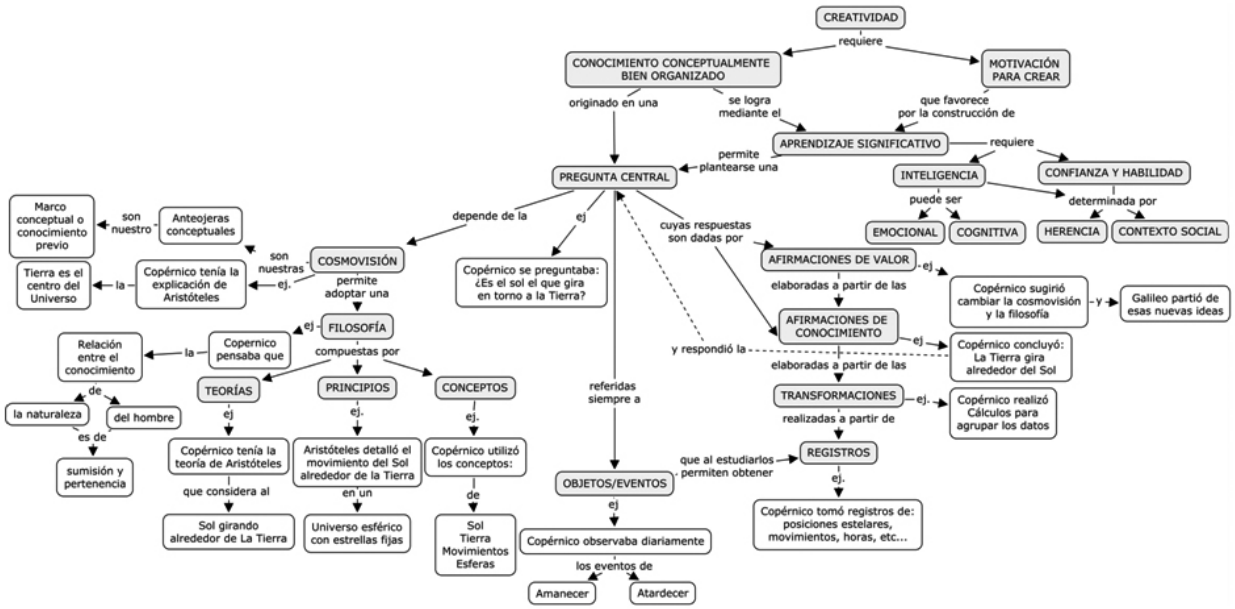


Figura 3. Mapa conceptual de la UVE con un ejemplo sobre teoría copernicana

2 Metodología utilizada en la investigación

Para responder a la pregunta planteada en nuestra investigación, recurrimos a implementar el uso de la UVE del conocimiento, apoyada por el uso de los mapas conceptuales, durante un curso sobre teorías y métodos de enseñanza de ciencias, dictado en el marco de la Maestría de Enseñanza de Ciencias Exactas y Naturales que se estudia en la Universidad Nacional del Comahue.

Una vez terminado el cursado de la mencionada asignatura, se realizó una encuesta a los estudiantes de ese postgrado, todos ellos profesores en actividad, tanto a nivel secundario como universitario. La encuesta utilizada por razones de espacio no se muestra. Se recibieron y analizaron como válidas 20 encuestas.

A los datos obtenidos como resultado de la encuesta, se le aplicaron técnicas de análisis multivariado. Como es sabido, el análisis multivariado explota las relaciones existentes entre las variables para lograr un análisis más profundo de la realidad subyacente en los datos observados. En este trabajo se utiliza el análisis de cluster.

2.1 Análisis de Cluster

Se utilizó el software Statistica – versión 6.0 para analizar los datos y se aplicó el método de encadenamiento UPGMA. (Cuadras, 1996). Distancia (x,y) = (Número de xi¹ yi)/i.

3 Resultados

La mayor parte de los encuestados poseen título docente y tienen una carga horaria de trabajo bastante cuantiosa que deja poco tiempo para su propia capacitación. El 40 % de los encuestados manifiestan que no han realizado cursos de capacitación sobre metodologías de enseñanza, el 15 % ha realizado de 0 a 2 cursos. Sólo pocos docentes se han capacitado en estos temas y, de aquéllos que lo hicieron, sólo el 30% dedicó más de 4 hs. semanales.

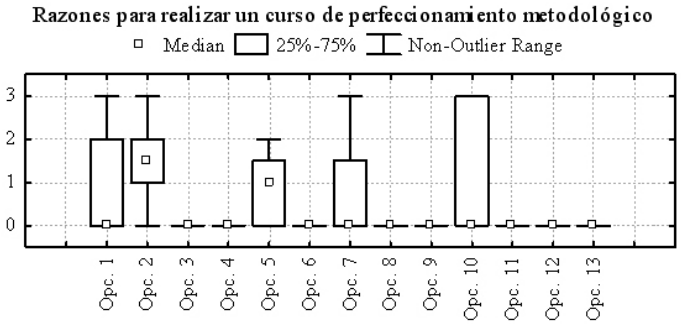


Figura 4. Razones para realizar un curso de perfeccionamiento metodológico.

El 65% de los encuestados poseen título universitario, mientras que el 35% tiene título de nivel terciario (En Argentina, se denomina de esta manera a los títulos de profesor entregados por los institutos de formación docente). Sólo el 25% de los encuestados se dedica a la investigación.

Algunas de las respuestas típicas, obtenidas a partir del análisis de las encuestas se muestran a continuación:

1) Porque los contenidos parecen interesantes, 2) Es de utilidad para entender los aspectos metodológicos en el aula, 3) Es un requisito para todos los docentes de la Provincia, 4) Es de utilidad para cumplir con el desarrollo de la currícula, 5) Me ayudará a mejorar mis habilidades académicas, 6) Es un perfeccionamiento fácil, 7) Es un requerimiento para trabajar interdisciplinariamente, 8) Me lo recomendaron los directivos, 9) Me lo recomendó un compañero, 10) Mejorará mis perspectivas profesionales, 11) Me queda bien por el horario, 12) Porque es un tema de actualidad y 13) Otra.

Las razones para capacitarse en metodologías de enseñanza fueron las opciones 1, 2, 5, 7 y 10. La mayor parte de los profesores encuestados piensan que la UVE ayuda a los alumnos a: 2) Participar activamente en la construc-

ción del conocimiento; 3) Integrar los distintos aspectos que conforman un cuerpo de conocimientos; 6) Analizar en profundidad los problemas que le son presentados; 7) Desarrollar una base de conocimiento relevante; 8) Desarrollar habilidades para la evaluación crítica; 11) Desarrollar el razonamiento creativo de acuerdo a una base de conocimiento integrada y flexible; 16) Elaborar sus propias afirmaciones de conocimiento y 17) Elaborar sus propias afirmaciones de valor.

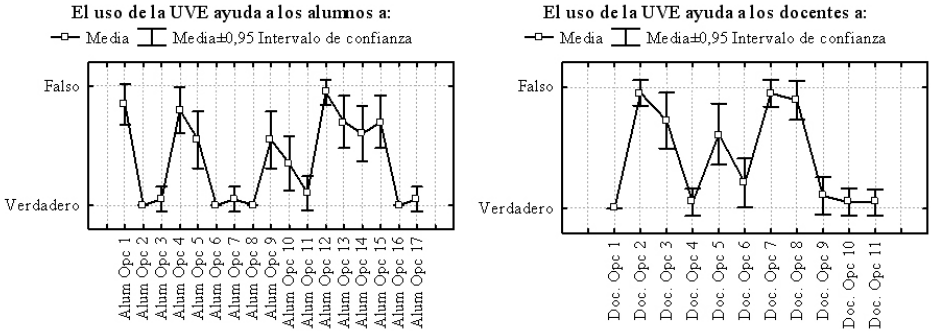


Figura 5. Opiniones sobre la utilidad del uso de la UVE en alumnos y docentes.

Con respecto a la ayuda que la UVE proporciona a los profesores, los encuestados opinaron lo siguiente: 1) Actuar como facilitador, orientador, tutor, guía, co-aprendiz o asesor; 4) Orientar la falta de conocimientos y habilidades hacia la mejora (evaluación formativa); 6) Diseñar la enseñanza basada en problemas abiertos; 9) Interactuar con los alumnos, quienes le ofrecen retroalimentación; 10) Comprometer a los alumnos a participar activamente en la resolución de problemas, y 11) Comprometer a los alumnos a identificar necesidades de aprendizaje, investigar, aprender, aplicar y resolver problemas.

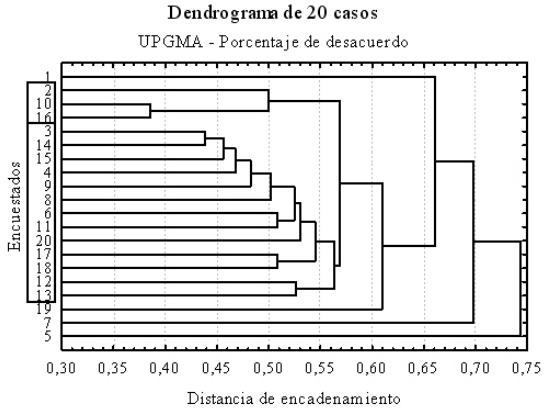


Figura 6. Similitudes y diferencias entre los encuestados. Se señalan los encuestados que responden en forma similar.

Las opiniones de los encuestados 10 y 16 son las más similares e integran el mismo agrupamiento con el encuestado 2. Sus coincidencias son sus profesiones y la opinión de cómo la UVE ayuda a los alumnos y a los docentes. En el segundo agrupamiento los encuestados 3 y 14 son los que opinan más parecido y su mayor similitud está en el uso de la UVE.

Las variables cuyo comportamiento son más similares en los agrupamientos 1, 2 y 3 son las opiniones sobre la ayuda de la UVE a alumnos y docentes.

En el agrupamiento 4 las variables con comportamiento similar fueron las opciones 4 y 9 sobre las razones para realizar un perfeccionamiento metodológico. Su coincidencia es que fueron seleccionadas por muy pocos encuestados.



Figura 7. Diagramas de variables sin ponderar, porcentajes promedios de desacuerdos

4 Conclusiones

Si bien gran parte de los encuestados no ha realizado cursos de perfeccionamiento metodológico previos a la maestría (en general por su abultada carga horaria), la consideran importante en su desarrollo profesional y en la adquisición de mejores habilidades para la enseñanza.

En cuanto al uso de la UVE, los resultados obtenidos, pueden ser considerados como muy positivos, tanto en la ayuda que brinda a los estudiantes como a los docentes.

Podemos además, considerar que el tema abordado es, en sí, de una importancia relevante, cuando se habla de ayudar a los estudiantes a ser creativos y responsables de su crecimiento personal, ya que adquieren habilidades propias del aprendizaje significativo, con su consiguiente fomento de la creatividad. Es particularmente promisorio en resultados que se verán reflejados en nuevas prácticas educacionales y en una nueva actitud hacia la ciencia como una forma de propender al desarrollo personal y comunitario y como una forma de garantizar una mayor igualdad social

por el acceso a recursos que permitan una mejor calidad de vida para más individuos.

Parafraseando a Novak (1984), podemos decir que durante casi un siglo, tanto la teoría como la práctica educativa han estado bajo la influencia de los psicólogos "behavioristas", quienes opinan que el aprendizaje es sólo un cambio en el comportamiento. Este trabajo, propone, a través del postgrado en enseñanza de las ciencias exactas y naturales, una visión alternativa, que se basa en un aprendizaje como "cambio en el significado de la experiencia", mediante la aplicación intensiva de las herramientas metacognitivas.

Las prácticas educativas tradicionales, no conducen al estudiante a captar el significado de la tarea a realizar; normalmente, no consiguen crear en ellos confianza en sus habilidades, es necesario que los estudiantes comprendan porqué y cómo la información nueva se relaciona con la que ellos ya tienen.

Así, nuestra conclusión es que este tipo de postgrados, puede producir resultados excelentes en las próximas décadas, siempre que podamos organizarnos y unirnos en tareas de docencia e investigación educativa, dentro de programas que tengan un marco explícito de teoría y conceptos directrices. Esto nos permitirá ser innovadores en la creación de acontecimientos educativos, recopilación de registros y transformación y difusión de los datos obtenidos.

Sintetizando, en base a nuestros resultados, es posible afirmar que el adecuado uso de la UVE del conocimiento y los mapas conceptuales puede fomentar la creatividad de los estudiantes.

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ESTUDIO COMPARATIVO SOBRE LA CONSTRUCCIÓN DE MAPAS CONCEPTUALES EN PEQUEÑOS GRUPOS E INDIVIDUALMENTE POR ALUMNOS DE GRADO DE LAS FACULTADES DE EDUCACIÓN FÍSICA Y FISIOTERAPIA EN LA DISCIPLINA DE BIOMECÁNICA

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Resumen. Se presenta un análisis cuantitativo para investigar si hay diferencia estadísticamente significativa en el resultado de la evaluación de mapas conceptuales construidos en pequeños grupos o individualmente. El estudio abarcó a 32 estudiantes de Educación Física y Fisioterapia, en la disciplina de Biomecánica. La aplicación del test no paramétrico de Mann-Whitney permitió concluir que hay diferencia estadísticamente significativa en las notas atribuidas a los mapas conceptuales en las dos situaciones, a favor de la construcción grupal; el mismo test hizo posible identificar el papel de cada variable de corrección de los diagramas: no se encontraron diferencias estadísticamente significativas para las variables estructura, proposiciones y ejemplos; para las variables jerarquía, relaciones cruzadas y presentación, fueron encontradas diferencias estadísticamente significativas.

1 Introducción

El acto de aprender no debe ser visto meramente como el almacenamiento de un conjunto de hechos en la memoria, sino también como la habilidad de utilizar recursos para encontrar, evaluar y aplicar informaciones (Lujan y DiCarlo, 2006). Esos autores destacan que los currículos están "empaquetados" con tantos contenidos que, para cumplir todo el programa, los profesores les transmiten a los alumnos lo que saben y éstos intentan almacenar tales informaciones en la memoria. También dicen que esos currículos "empaquetados" dejan poco tiempo para que los alumnos profundicen en los conocimientos o para desarrollar habilidades a largo plazo como el pensamiento crítico, la resolución de problemas y la comunicación.

Una posibilidad para contornar ese problema sería, de acuerdo con Vander (1994), "desempaquetar el currículo y reducir la cantidad de informaciones que los alumnos tienen que memorizar, ayudándoles a hacerse sujetos activos, independientes y solucionadores de problemas". Sin embargo, no siempre es posible disminuir la cantidad de contenidos que integran los currículos de las disciplinas de los cursos de grado. Por otro lado, la alternativa propuesta por Vander (1994) es muy simplista y, por sí sola, difícilmente resolvería el problema de la tendencia a un aprendizaje mecánico, que representa el extremo opuesto de un aprendizaje significativo.

Hay que recordar que aprendizaje significativo es el concepto central de la teoría de Ausubel que, según Moreira (2006, p. 14), es el proceso por el cual una nueva información se relaciona, de manera sustantiva (no literal) y no arbitraria, a un aspecto específicamente relevante de la estructura cognitiva del individuo. El autor explica que las nuevas informaciones (nuevas ideas, conceptos, proposiciones) pueden ser aprendidos significativamente (y retenidos) cuando otras ideas, conceptos, proposiciones relevantes e inclusivos estén adecuadamente claros y disponibles en la estructura cognitiva del sujeto y funcionen interactivamente, como punto de anclaje de las primeras.

Para que haya aprendizaje significativo, el material que se ha de aprender debe ser potencialmente significativo para el alumno, es decir, relacionable a su estructura cognitiva de forma no arbitraria y no literal; además, el alumno debe manifestar una disposición para aprender, o sea, una disposición de relacionar el nuevo material de manera sustantiva y no arbitraria a su estructura de conocimiento (Moreira, 1999; Moreira y Masini, 2006).

Totalmente compatible con la Teoría del Aprendizaje Significativo de Ausubel es la Teoría de los Campos Conceptuales de Vergnaud (1990), para el cual, el núcleo del desarrollo cognitivo es la conceptualización (Moreira, 2004). La conceptualización es un proceso a través del cual los conceptos se hacen significativos por medio de una variedad de situaciones, que dan sentido a los conceptos, lo que justifica la definición de campo conceptual, sobre todo, como

un conjunto de situaciones (op. cit.). En esa teoría, la relevancia de la acción del sujeto es enfatizada como mediadora de la evolución conceptual. Por tanto, es importante ofrecerles a los alumnos una gran cantidad de situaciones en diferentes grados de complejidad (Caballero, Moreira y Rodríguez, 2008).

Desde ese punto de vista, el uso de mapas conceptuales se presenta como una herramienta adecuada de análisis del conocimiento de los alumnos, teniendo en cuenta que se trata de diagramas jerárquicos que pretenden reflejar la organización conceptual de una disciplina o contenido específico o parte de ella o de él (Moreira, 2006).

Novak y Gowin (1984) defienden que el mapa conceptual es una técnica que permite la externalización de conceptos y proposiciones, por tanto, permite que los profesores y alumnos cambien, presenten, negocien sus puntos de vista sobre la validez de una determinada relación proposicional, o reconocer la falta de relaciones entre conceptos que sugieren la necesidad de un nuevo aprendizaje. Los autores también destacan que, frecuentemente, los mapas conceptuales han sido utilizados también para revelar concepciones alternativas, ya que, muchas veces, es posible percibir relaciones falsas entre los conceptos presentados en el diagrama.

Se destaca el potencial de la construcción de mapas conceptuales en colaboración. En el estudio conducido por Iraizoz Sanzol y González Garcia (2008) se pudo de manifiesto que los mapas construidos en grupo fueron más ricos que los construidos individualmente. Poveda y Zaballo (2008) comentan que el trabajo con mapas conceptuales no sólo beneficia los aprendices novatos, sino también a los especialistas por solicitar que verbalicen lo que saben, que estructuren cognitivamente las informaciones que tienen que transmitir y que desempeñen el papel del profesor, auxiliando a sus compañeros a desarrollar procesos cognitivos de atención, en una perspectiva totalmente compatible con la Teoría de la Mediación de Vygotsky. Otra ventaja es que auxilia en habilidades importantes en situación de aprendizaje, como el trabajo en grupo, la generación de sinergias y empatías entre miembros del grupo y las comunicaciones tanto oral como escrita (San Martín Echeverría, Albisu García y González García, 2008).

Heinze-Fry (2004) encontró resultados positivos relacionados al uso de mapas conceptuales presentados por el instructor durante la clase y con relación a los producidos individualmente por los estudiantes, pero se sorprendió con el mayor potencial del mapa conceptual en pequeños grupos, juntamente con la presentación de los mismos en clase. En ese mismo sentido, Poveda, Sanzol y Oneca (2006) consideran que un enfoque constructivista debe incluir mapas conceptuales como estrategia didáctica por forzar el estudiante a negociar, compartir significados y reflexionar sobre lo que él mismo construyó.

El ambiente educacional en colaboración parece ideal y adecuado para favorecer esa negociación. Aún cabe citar que el aprendizaje significativo, cooperativo y compartido posibilita, también, la participación de estudiantes con dificultades escolares, ya que está basado en problemas reales, en experiencias significantes y en grupos, en los cuales la distribución de tareas permita contar con cada tipo de inteligencia (Venditti y Sabba, 2006).

Añez, Ferrer y Velzasco (2006), al evaluar el aprendizaje significativo alcanzado por estudiantes de un curso Propedéutico de Química, a través de la aplicación de mapas conceptuales, como técnica de explotación de la estructura cognitiva a través del trabajo cooperativo, observaron un avance significativo en las proposiciones explicativas del tema trabajado, aunque en el resto de los criterios (jerarquía, relaciones cruzadas y ejemplos), no se hayan verificado avances. Los autores explican que la ausencia de relaciones cruzadas puede haber ocurrido, entre otros motivos, debido también a la insuficiencia de la mediación cognitiva del profesor al aclarar dudas surgidas en los alumnos durante el desarrollo de las actividades, lo cual refuerza la importancia de la mediación del profesor en el proceso de elaboración de los mapas conceptuales.

En cuanto a la preferencia por trabajar en grupo o individualmente, Mancinelli (2006) observó que los alumnos que integraron su observación prefirieron trabajar solos porque percibieron el mapa conceptual como una secuencia individual de situaciones, que expresa la peculiaridad del proceso de aprendizaje.

Scott, Pelley y Taylor (2006) verificaron que los estudiantes aparentaron preferir el mapa conceptual en grupo en comparación con el trabajo individual, pues las actividades en grupo hicieron que ellos enseñasen a otros colegas al mismo tiempo que aprendieron nuevas formas de relacionar conceptos. En esa perspectiva de trabajo en grupo, los alumnos acaban reconociendo la importancia del intercambio de ideas y de la ayuda a los colegas (Gouveia y

Valadares, 2004; Mancinelli, 2006; Scott, Pelley y Taylor, 2006), además de aprender sobre la importancia del respeto a los diferentes puntos de vista, de la tolerancia y del trabajo en equipo (Gouveia y Valadares, 2004; Gomez, 2006; Trujillo-Vargas, Jaramillo-Ramírez y Gutiérrez, 2006; Scott, Pelley y Tayor, 2006; Arroyo, 2004; Ramírez, 2004; Afamagasa-Fuata'i, 2004).

2 Metodología de Estudio

El objetivo de este estudio fue verificar si hubo diferencias en la calidad de los mapas conceptuales (referentes a los contenidos de cinética, o dinámica, que explican los cambios en el movimiento) producidos en pequeños grupos y los producidos individualmente por 32 alumnos de grado de Educación Física y Fisioterapia en la disciplina de Biomecánica en un Centro Universitario localizado en el municipio de Canoas, RS, Brasil.

Los datos fueron recogidos en el primer semestre lectivo de 2010. El primer día de clase los alumnos recibieron instrucciones y entrenamiento para la elaboración de mapas conceptuales. La propuesta pedagógica inicial fue pautada por la construcción de mapas conceptuales en pequeños grupos sobre los asuntos tratados en las clases expositivas de la disciplina, por la resolución de problemas-tipo y problemas abiertos y por algunas clases prácticas, realizadas en el gimnasio (con la finalidad de auxiliar en la comprensión de conceptos relacionados a la cinética) y en la piscina (con la finalidad de auxiliar en la comprensión de conceptos relativos a la mecánica del movimiento humano en los fluidos).

La evaluación de la disciplina fue concretada por medio de dos instrumentos: a) presentación de los mapas conceptuales construidos colectivamente y b) examen escrito individual.

Turns, Atman y Adams (2000) sostienen que la construcción de mapas conceptuales como examen final de un curso es una forma de facilitarle al estudiante el desarrollo de un entendimiento global de los contenidos. Sin embargo, eventualmente ocurre, con ocasión de los trabajos en grupo, que algún alumno se exima de la responsabilidad de la participación y/o presentación del trabajo. Para evitar ese problema (o, por lo menos, minimizar ese tipo de situación), se acordó con los alumnos que el miembro del grupo responsable de la presentación de los mapas conceptuales sería determinado a través de sorteo y ese sorteo se realizaría solamente el día de la evaluación.

Los criterios de evaluación de los mapas conceptuales, adaptados de los criterios propuestos por Novak y Gowin (1984) y que fueron previamente presentados y discutidos con los alumnos, fueron:

A. Estructura (2 puntos)
- ¿Todos los cuadros contienen solamente conceptos?
- ¿Todos los conceptos están relacionados a otros conceptos?
- ¿Todas las líneas poseen palabras de relación?
- ¿Los conceptos se repiten?

B. Proposiciones (2 puntos)
- ¿Las proposiciones expresan una relación válida entre los conceptos?
- ¿Las proposiciones son sólo superficiales?

C. Jerarquía (1 punto)
- ¿Se puede percibir cuáles son los conceptos más generales e inclusivos y cuáles son los conceptos más específicos?

D. Relaciones cruzadas (1 punto)
- ¿Existen relaciones entre conceptos de diferentes niveles de jerarquía?
- ¿Esas relaciones son válidas?

E. Ejemplos (1 punto)
- ¿Se mencionaron (aunque sea oralmente, durante la presentación oral del mapa conceptual) situaciones que sirviesen de ejemplo o diesen sentido a los conceptos?
- ¿Esas situaciones eran diferentes de las presentadas en clase por la profesora?

F. Presentación oral (3 puntos)
- ¿El mapa fue presentado, explicado, o sólo leído?
- ¿El responsable de la presentación profundizó algún conocimiento sobre el tema o se limitó a los conceptos contenidos en el mapa?

Hay que destacar que en la propuesta de ese estudio no se utilizó la comparación de los mapas de los alumnos con un mapa de referencia por entender que ese tipo de procedimiento acaba transformando el mapa de referencia en una especie de categoría, limitando la corrección y la valoración de aspectos destacados por los alumnos que eventualmente no estén presentes en el mapa del especialista. Además, dependiendo del uso, la comparación del mapa del alumno con un mapa de referencia puede ser entendida como una forma comportamentalista de evaluación, ya que, por ejemplo, el hecho de que un alumno no incluya algún concepto que esté contemplado en el mapa de referencia puede ser interpretado como error.

Fue dada a los alumnos la opción de trabajar en una perspectiva recursiva, es decir, pudieron construir sus mapas conceptuales, presentarlos al gran grupo y/o a la profesora, discutir y negociar el tema en cuestión y rehacer el mapa conceptual hasta llegar a una versión final que será presentada el día de la evaluación. En las presentaciones realizadas sin valer nota, los alumnos pudieron escoger quién presentaría el mapa conceptual, pero la profesora dejaba claro que el día de la evaluación sería sorteado un único miembro del grupo para proceder a la presentación.

Como ya se mencionó anteriormente, además de las presentaciones de los mapas conceptuales construidos en pequeños grupos, los alumnos también fueron evaluados por un examen escrito individual, aplicado una semana después de las referidas presentaciones, e incluyendo problemas-tipo, cuestiones cualitativas y un mapa conceptual. La corrección de los mapas conceptuales construidos en el momento del examen fue realizada con los mismos criterios de corrección que los mapas conceptuales construidos en pequeños grupos, salvo por el hecho de que, en lugar de una presentación verbal de los diagramas, los alumnos deberían presentar una descripción por escrito explicando el diagrama.

3 Análisis de los datos y discusión de los resultados

El objetivo del presente estudio fue verificar si hubiera diferencias en las notas de los alumnos de grado de Fisioterapia y Educación Física al construir mapas conceptuales en pequeños grupos o individualmente, para los conceptos relativos a la cinética, en una disciplina de Biomecánica. En las dos situaciones, la puntuación de los mapas conceptuales fue atribuida utilizando una escala de 0 a 10 puntos, basada en los criterios ya presentados.

Los datos referentes a las notas de los mapas conceptuales construidos colectivamente y a las notas de los mapas conceptuales construidos individualmente, con ocasión del examen escrito, fueron sometidos al test de normalidad de Kolmogorov-Smirnov (K-S) y solamente las notas de los mapas conceptuales construidos individualmente presentaron distribución normal (con nivel de significancia de 0,200).

Para verificar si hubo diferencia en las notas de los alumnos al construir mapas conceptuales en pequeños grupos o individualmente, se utilizó el test no paramétrico de Mann-Whitney (U) para dos muestras independientes. Los resultados del test de Mann-Whitney ($U = 264$) mostraron que las dos distribuciones difieren en tendencia central con significancia de 0,001 (considerando $p < 0,05$). De ese modo, es posible concluir que hay diferencia estadísticamente significativa en las notas de los alumnos cuando construyen mapas conceptuales en pequeños grupos y cuando los construyen individualmente.

Una vez verificada la diferencia estadísticamente significativa para las notas de los mapas conceptuales en las dos situaciones en el grupo observado, se intentó entender qué aspectos influían en esa diferencia. Se verificó que la media de las notas de los alumnos, al construir mapas conceptuales colectivamente, fue de 8,4 puntos, con desviación estándar de 1,4 puntos, la nota más baja fue equivalente a 6 puntos y la más alta, a 10. En el caso de los mapas conceptuales construidos individualmente, la media fue 6,4 puntos, con desviación estándar de 2,5, la nota más baja fue equivalente a 1,5 puntos y la más alta, a 10.

También se realizó el test de correlación de Spearman para verificar si hubo correlación entre las dos notas. Se encontró correlación de 0,63 a un nivel de significancia de 0,000. Aunque haya diferencia estadísticamente significativa entre las notas en las dos formas de construcción de mapas conceptuales, se puede decir que hay una correlación media entre las notas en las dos situaciones.

Para intentar entender las razones que justifican las diferencias encontradas, se aplicó el test no paramétrico de

Mann-Whitney para cada criterio de corrección por separado. No se encontraron diferencias estadísticamente significativas para las variables estructura (U = 510; sig. = 0,975), proposiciones (U = 467; sig. = 0,500) y ejemplos (U = 495; sig. = 0,805). Sin embargo, en las variables jerarquía (U = 209,5; sig. = 0,000), relaciones cruzadas (U = 156; sig. = 0,000) y presentación (U = 290; sig. = 0,002), se encontraron diferencias estadísticamente significativas.

La variable estructura tiene que ver con la construcción de los mapas conceptuales y quedó de manifiesto que los alumnos parecían dominar las reglas de construcción, explicadas no solamente a través del entrenamiento ofrecido el primer día de clase, sino también debido a las instrucciones dadas por la profesora siempre que los alumnos se lo solicitaban.

La variable proposiciones tiene que ver con las relaciones entre los conceptos expresadas a través de palabras de relación sobre las líneas que conectan los conceptos. La media de la nota de las proposiciones presentadas en los mapas construidos en grupo fue de 1,7 (de un total de 2 puntos), con desviación estándar de 0,41 y la media de la nota de las proposiciones presentadas en los mapas construidos individualmente fue de 1,6, con desviación estándar de 0,44, o sea, en cualquiera de las situaciones, los alumnos fueron capaces de construir proposiciones válidas a partir de las relaciones entre los conceptos.

La variable ejemplos tiene que ver con la capacidad del alumno de indicar situaciones que den sentido a los conceptos. No hubo diferencia significativa entre los ejemplos indicados en los mapas conceptuales construidos en pequeños grupos y los construidos individualmente.

La variable jerarquía concierne a la percepción que tiene(n) el(los) sujeto(s) que construye(n) el mapa conceptual a respecto de cuáles son los conceptos más generales, más inclusivos y cuáles son más específicos; es decir, de acuerdo con la teoría del aprendizaje significativo de Ausubel, a través de la jerarquía en un mapa conceptual es posible verificar si el autor consigue realizar una diferenciación progresiva del contenido que se está aprendiendo.

En este criterio se encontraron diferencias estadísticamente significativas, la media de puntuación (de un total de 1 punto) para la jerarquía en los mapas conceptuales construidos en pequeños grupos fue de 0,90, con desviación estándar de 0,29 y la media en los mapas conceptuales construidos individualmente fue de 0,32 con desviación estándar de 0,46.

Por otro lado, en el criterio relaciones cruzadas, que se refiere a relaciones entre diferentes niveles de jerarquía, no se encontró diferencia significativa, la media de puntuación (también de un total de 1 punto) para los mapas conceptuales construidos en pequeños grupos fue de 0,96 con desviación estándar de 0,12 y la media en los mapas conceptuales construidos individualmente fue de 0,32, con desviación estándar de 0,45. Hay que recordar que el criterio de relaciones cruzadas puede ser interpretado a la luz de la teoría de Ausubel como la capacidad que tiene el autor del mapa conceptual de realizar una reconciliación integradora entre conceptos de diferentes niveles de jerarquía. Los alumnos del grupo observado parece que dominaron los dos procesos (diferenciación progresiva y reconciliación integrativa) cuando trabajaron en pequeños grupos, pero no demuestran la misma habilidad al construir el mapa conceptual sobre el mismo asunto individualmente.

También llama la atención el hecho de haber sido encontrada diferencia estadísticamente significativa entre las medias en el criterio presentación. La media de la presentación de los mapas conceptuales construidos en pequeños grupos (de un total de 3 puntos) se quedó en 2,56, con desviación estándar de 0,66, mientras que la media de las presentaciones de los mapas conceptuales construidos individualmente fue de 1,89, con desviación estándar de 0,96. Hay que destacar que las presentaciones de los mapas conceptuales construidos en grupo fueron realizadas por un único individuo, sorteado el día de la evaluación y que ese criterio de sorteo fue utilizado para estimular que todos participasen activamente en la construcción del mapa conceptual, y se responsabilizasen de su presentación.

Las presentaciones fueron realizadas a la profesora de la disciplina y al gran grupo a través de exposición oral, los alumnos mostraron el mapa conceptual construido a través de un proyector multimedia. Por otro lado, la presentación del mapa conceptual construido individualmente con ocasión del examen (aplicado una semana después de las presentaciones orales), fue realizada por escrito. Por eso, es prudente considerar que varios de los alumnos pueden presentar dificultades en la producción textual, lo que puede justificar una puntuación más baja en ese criterio. Otra

constatación realizada por la profesora es que muchos alumnos simplemente no prestan atención a las presentaciones de los compañeros, preocupándose tan sólo de sus propias presentaciones o de los representantes de su grupo. Tal vez, si los alumnos aprovechasen mejor las discusiones sobre los mapas conceptuales presentados por los colegas, así como, la mediación de la profesora, los resultados serían diferentes.

En las Figuras 1, 2 y 3 se presentan, respectivamente, a guisa de ejemplos, un mapa conceptual elaborado por un de los grupos y dos mapas elaborados por diferentes miembros de ese mismo grupo, de forma individual. La inclusión de conceptos sobre la cinemática no era exigida en la construcción de los mapas individuales y, por ese motivo, no fue tomada en cuenta en la evaluación.

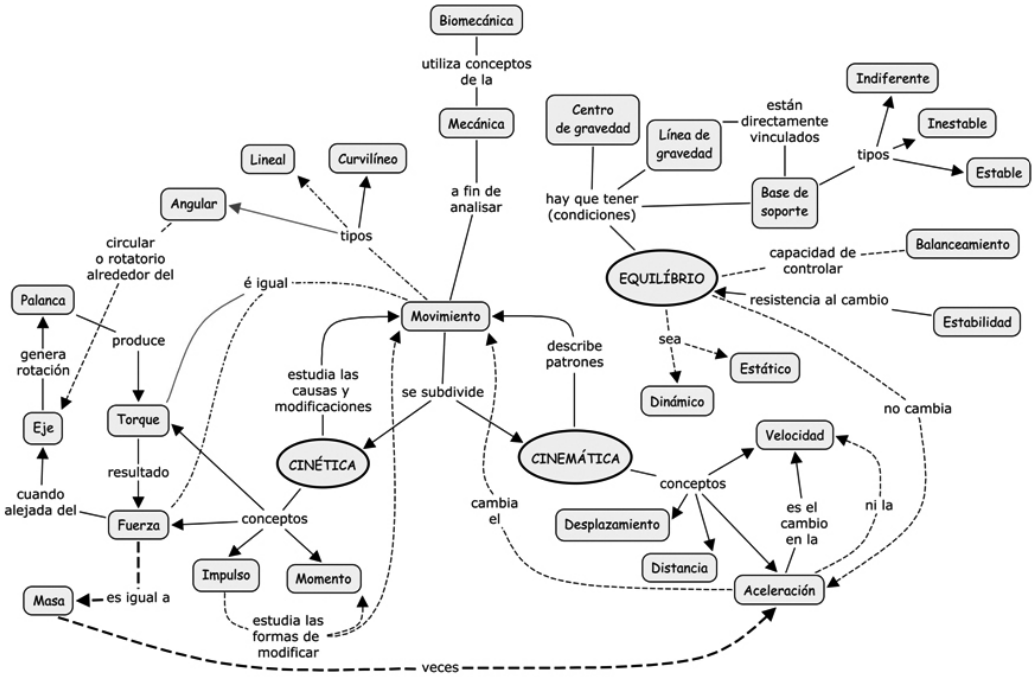


Figura 1. Mapa conceptual construído por un pequeño grupo de estudiantes de Biomecánica

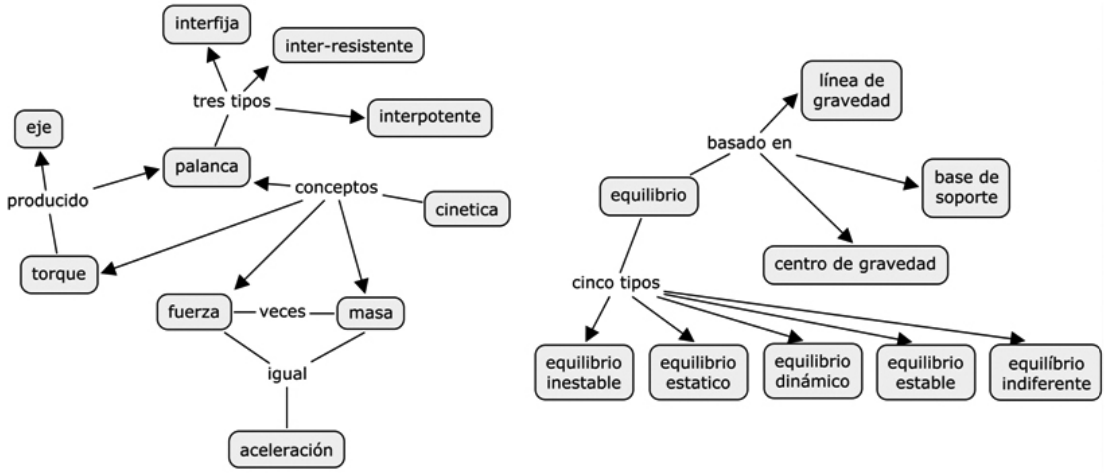


Figura 2. Ejemplo de un mapa conceptual con debilidades, construido individualmente por el estudiante E.A. del mismo grupo del mapa de la Figura 1

4 Resumen

Se presenta un análisis cuantitativo para investigar si hay diferencia estadísticamente significativa en el resultado de la evaluación de mapas conceptuales construidos en pequeños grupos o individualmente. El estudio abarcó a 32 estudiantes de Educación Física y Fisioterapia, en la disciplina de Biomecánica. La aplicación del test no paramétrico de Mann-Whitney permitió concluir que hay diferencia estadísticamente significativa en las notas asignadas a los mapas conceptuales en las dos situaciones, a favor de la construcción grupal; el mismo test hizo posible identificar el papel de cada variable de corrección de los diagramas: no se encontraron diferencias estadísticamente significativas para las variables estructura, proposiciones y ejemplos; para las variables jerarquía, relaciones cruzadas y presentación, fueron encontradas diferencias estadísticamente significativas.

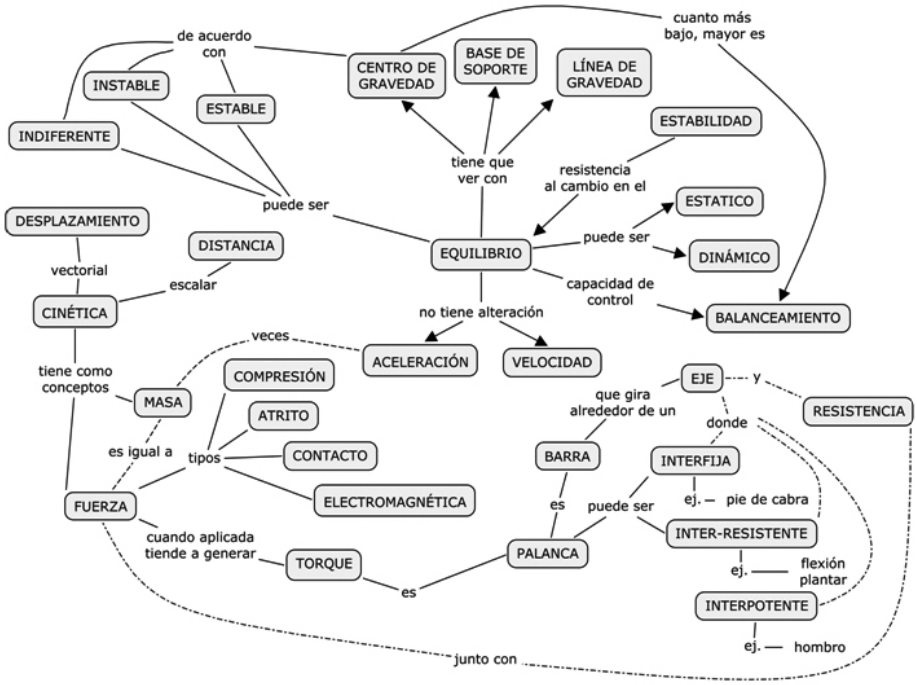


Figura 3. Ejemplo de un buen mapa conceptual construido individualmente por la estudiante M.T. del mismo grupo del mapa de la Figura 1

5 Agradecimiento

Los autores le agradecen la profesora Rosiane Karine Pick por el auxilio en el tratamiento estadístico de los datos.

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EVALUACIÓN DE APRENDIZAJES CON MAPAS CONCEPTUALES: PORTAFOLIOS DE MAPAS CONCEPTUALES

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Abstract. La evaluación del proceso de aprendizaje y no sólo del resultado por sí mismo, es el punto de interés de este artículo. Por evaluación del aprendizaje vamos a entender tanto la comprensión del conocimiento alcanzado, como del proceso mismo que nos lleva ese conocimiento, para ir creando la mejor estrategia de aprendizaje. Entonces se sustenta, describe y analiza una experiencia concreta, la elaboración de portafolios de mapas conceptuales por parte de estudiantes, como medio para sistematizar el propio proceso de aprendizaje y conocimiento. La evaluación de los mapas requirió de la definición previa de nueve criterios, que posteriormente fueron incorporados en el diseño de un instrumento de calificación. Por su parte la mediación docente se convirtió en la principal herramienta para la toma de conciencia y autorregulación del aprendizaje. Dadas estas condiciones, la representación del conocimiento fue dando lugar a un ambiente de confluencia entre el aprendizaje y la evaluación. Esta experiencia fue desarrollada en un curso de la carrera de formación de docentes para la educación preescolar de la Universidad de Costa Rica.

1 Introducción

La evaluación de aprendizajes es un elemento inherente a la didáctica, más sin embargo con bastante regularidad la desligamos del proceso de aprendizaje y la autorregulación, convirtiéndola en un fin en sí misma.

En un esfuerzo por tratar de disminuir la brecha entre evaluación y aprendizaje, he trabajado con el uso de la pregunta pedagógica, como herramienta de mediación (Chacón, 2006), en mi docencia universitaria. Esta es la razón por la cual en otras oportunidades he centrado mi interés en el uso apropiado de la pregunta pedagógica, más sin embargo, en esta ocasión abordo el tema del aprendizaje desde la perspectiva de la confluencia con la evaluación. No por ello el tema de la pregunta pedagógica estará ausente.

El trabajo con mapas conceptuales constituye la experiencia que más me ha acercado a esa confluencia. Después de algún trabajo previo, entre los años 2005 y 2006, desarrollo con mis estudiantes los portafolios de mapas conceptuales dentro del curso de Artes del Lenguaje, con la intención de que sistematizaran sus conocimientos y evidenciaran en cierta medida sus propios procesos.

Para iniciar este artículo se ofrece inicialmente una breve descripción del contexto en que se desarrolla la experiencia, luego un referente conceptual. En tercer lugar se describe el proceso metodológico para la elaboración de los portafolios, lo cual se enlaza con el tema de lo evaluativo, al describir la organización y utilización de algunos instrumentos. Posteriormente se presentan algunos resultados para finalizar con algunas consideraciones finales.

2 El curso de Artes del Lenguaje 2

Este curso parte de la carrera de Educación Preescolar de la Sede Rodrigo Facio de la Universidad de Costa Rica. Su objetivo es estudiar el proceso de comunicación y su situación pedagógica dentro del aula preescolar. Incluye tres temáticas focales: primero, la relación entre pensamiento, lectura y grafismo; segundo, el desarrollo de la lectura y grafismo, y tercero, la didáctica para promover ese desarrollo. La experiencia que aquí se sistematiza corresponde al año 2006.

Particularmente el grupo de estudiantes que participó en ese año estuvo constituido por 28 personas entre los 20 y 21 años.

3 Referente conceptual que sustenta la utilización de mapas conceptuales

Aprendizaje significativo y el efecto relevante

Se reafirma lo ya propuesto por Ausubel, al señalar que la significatividad se produce cuando se da una conexión o anclaje de información, es decir cuando una nueva información se conecta a conceptos relevantes preexistentes (subsunsores) en la estructura cognitiva de una persona. (Ausubel, Novak y Hanesian, 1987).

En el campo de la educación un aprendizaje cobra sentido cuando el efecto se produce no sólo para el individuo en sí mismo, sino cuando el efecto trasciende hacia el contexto, al producirse cambios en la manera de relacionarse y concebir el mundo. (zona potencial de desarrollo próximo según Vigotsky).

Evaluación de los aprendizajes

Evaluar significa valorar algo, teniendo como referente un propósito, una intencionalidad. En el contexto del aprendizaje significa tener claridad en cuanto al conocimiento que se espera obtener, entendiendo que el conocimiento es una compleja estructura, integrada por un conjunto de saberes y caracterizada por la visión de quien aprende. Por tanto, evaluar aprendizajes significa, no sólo prestar atención al "resultado de aprendizaje", sino a la forma en cómo éste se construye. Aprender a aprender también se constituye en un conocimiento.

Ahora bien, como toda evaluación tiene como finalidad la toma de decisiones, en el caso del aprendizaje es la autorregulación la estrategia más importante, cuyas intenciones básicas son las siguientes:

- Ofrecer al constructor de conocimiento evidencia de la forma en cómo construye su conocimiento, para que tome conciencia y mejore sus capacidades de aprendiz.
- Ofrecer al mediador del aprendizaje evidencia de la forma en cómo el constructor de conocimiento, elabora procesualmente su conocimiento, para diseñar la forma de intervenir en la zona de aprendizaje del constructor.
- Establecer, tanto al constructor de conocimiento como al mediador de aprendizaje, si el conocimiento logrado coincide con las intenciones iniciales establecidas, se aleja de ellas o las trasciende.

Los procesos de evaluación pueden o no llevar a establecer calificaciones cuantificables, en el caso de que así ocurra, debe existir una clara definición de criterios de evaluación.

La mediación para la evaluación

Hablar del papel mediador docente nos lleva a prestar atención a las implicaciones pedagógicas derivadas de la Teoría del Aprendizaje Significativo (Ausubel, 1989), de la intervención en la zona de desarrollo potencial, según Vigotsky (1963) y de la intervención entre el sujeto y el objeto, según Piaget (Badilla, Chacón y Jinesta, 1995). Todos coincidentes en realizar una intervención pertinente, que centre su atención en el proceso de aprendizaje.

En el contexto de la evaluación, el papel mediador debe ayudar a dar insumos al aprendiz, sobre lo que está conociendo y cómo lo está conociendo, es allí donde entra en juego el empleo de las preguntas pedagógicas. En el caso de los mapas conceptuales, hablamos de preguntas generadoras, de verificación, de ampliación, de animación y metacognitivas. (Chacón, 2006). El mediador es quien promueve el acercamiento entre la pregunta generadora inicial y las posibles respuestas. Una de sus funciones será favorecer el proceso continuo entre desequilibrio y equilibrio cognitivo, según lo define Piaget (1975).

El mapa conceptual: herramienta de sistematización del aprendizaje y evaluación

Para Novak (1998), el mapa conceptual, corresponde a una herramienta que permite representar el conocimiento con aplicación en el marco escolar o empresarial, "son asimismo poderosas herramientas para facilitar el aprendizaje, así como instrumentos de evaluación" (Novak, 1998:30). En sí, los mapas conceptuales representan gráficamente las relaciones significativas entre conceptos que adquieren forma de proposiciones. Según Boggino (1997), el mapa cog-

nitivo, es una representación gráfica de una imagen mental y por tanto es singular e individual; son de carácter social y responden a una determinada disciplina. Se desprende entonces que aunque el aprendizaje se produce en un ambiente de colaboración, finalmente el resultado, o sea el conocimiento, es individual y por tanto singular. Más concretamente en el campo de la evaluación, los mapas conceptuales han sido utilizados de diversas maneras, por enunciar algunas, las siguientes:

- Para identificar la forma en que se organiza el pensamiento: se valora la forma, la estructura topológica. Por ejemplo, identificando los 7 niveles propuestos por Cañas, Miller y otros. (2006)
- Para determinar el resultado de un contenido estudiado: además de la estructura topológica se valora la coherencia y veracidad de las proposiciones.
- Para identificar el proceso de construcción y representación del conocimiento: además de la estructura topológica y la calidad de las proposiciones, se valora el proceso, las modificaciones que se van realizando desde el inicio del mapa, dando seguimiento a las reelaboraciones, en contenido y forma.
- Se utilizan como "instrumentos de evaluación en sí mismos": estableciendo proposiciones abiertas o semiarbiertas (Araya y Alonso, (2008), para evaluar una situación en particular.

La tercera de estas formas es la que se asumió en la experiencia aquí analizada. El mapa permite evaluar el contenido, así como versatilidad del pensamiento (Chacón, 2004)

4 Metodología de elaboración de mapas conceptuales para el curso Artes del lenguaje 2.

Se explica aquí la forma como el grupo de estudiantes elaboró sus portafolios de mapas conceptuales, además, la forma como se desarrolló la mediación docente, la evaluación y calificación del portafolio.

El portafolio de mapas conceptuales

El seguimiento del aprendizaje estuvo orientado por la metodología misma del curso. Entre otras actividades, las estudiantes debían ir elaborando un portafolio virtual de mapas conceptuales, que representaba el 50 % de la nota de curso y cuyo origen estuvo en el planteamiento de 5 preguntas focales, y la elaboración de un mapa conceptual por cada pregunta. Las cinco preguntas estaban previamente establecidas en el programa de curso, acordes a los objetivos del mismo. Estas preguntas fueron:

- A. ¿Cuál es la relación entre aprendizaje, pensamiento y desarrollo gráfico?
- B. ¿En qué consisten las etapas del desarrollo gráfico y lectura, a nivel preescolar?
- C. ¿Cuáles son las capacidades que se necesitan durante el proceso de desarrollo del grafismo?
- D. ¿En qué consiste la didáctica del desarrollo gráfico, a utilizar en el nivel preescolar?
- E. ¿En qué consisten los métodos de lecto-escritura que se utilizan en Costa Rica?

Concretamente el portafolio se iba construyendo durante el curso, pero al final del mismo cada portafolio, ya fuera digital o físico, debía contener lo siguiente:

- Los mapas finales (A-B-C-D-E), como resultado del proceso de construcción.
- Los mapas de proceso, es decir las diferentes versiones para llegar a los mapas A, B, C, D, E (la cantidad de versiones varió de una persona a otra).
- Al menos 5 insumos adicionales que complementaban la construcción del conocimiento: prácticas sobre elaboración de proposiciones, lecturas, informes, etc.
- Las observaciones a los mapas dadas por la profesora.

La construcción de cada mapa

Cada mapa debía integrar lo que la estudiante ya sabía, más lo que había logrado ampliar, utilizando como insumos, las lecturas previas, lo indagado, lo observado en los centros educativos y lo discutido en clase. También se dio la alternativa de realizar los mapas en parejas. Cada mapa conceptual iniciaba con una versión inicial que se iba mejorando con la mediación pedagógica. Cada quince días se iniciaba un nuevo mapa conceptual. Valga señalar que la

construcción de mapas estuvo precedida por prácticas que se realizaron en un curso anterior donde adicionalmente se dio acceso al programa Cmap Tool.

La mediación docente y la valoración del aprendizaje

La mediación docente estuvo constituida por entrega de informes, la atención de estudiantes de tutorías, además de la utilización de dos instrumentos: un registro de entrega de mapas conceptuales y un instrumento de valoración del portafolio de mapas conceptuales. A continuación el detalle de estos aspectos:

Informes de valoración: fueron elaborados (de mi parte) para cada persona o pareja de estudiantes. El primer informe fue el más amplio e incluía tres aspectos: a) un recordatorio sobre los elementos requeridos en la elaboración de proposiciones. b) Una transcripción de las proposiciones elaboradas en el mapa, para lo cual se utilizó la aplicación "Exportar como proposiciones" del menú de Archivo de Cmap Tool, esta aplicación permitió la revisión de las proposiciones de manera horizontal, en aspectos diversos aspectos, los cuales se indican en el recuadro al lado derecho. c) Una serie de preguntas pedagógicas para repensar algunos conceptos fundamentales de la temática estudiada. Finalmente se invitaba a la estudiante a una sesión de tutoría.

La revisión de proposiciones de manera horizontal permitió lo siguiente:

- Revisión de conceptos
- Estructuración de proposiciones como base de los Mapas Conceptuales.
- Verificación de los conceptos y proposiciones.
- Ampliación conceptual del mapa.
- Sugerir relaciones.
- La organización general del mapa.
- Revisión en el propio mapa.
- Reflexión metacognitiva.
- Aspectos logísticos: ampliación de lapsos de entrega de los mapas, forma de entrega.
- Mejoramiento en el uso de la herramienta

Estos informes eran enviados a cada estudiante o pareja de estudiantes mediante correo electrónico, o se entregaban de manera personal de manera impresa o digital.

Los informes para los mapas posteriores, fueron variando según los requerimientos de cada persona.

Las tutorías: se organizó un horario de tutorías (mañana, tarde, noche). En la puerta de oficina se colocó el horario y las estudiantes se anotaban a conveniencia. Se otorgaba media hora de atención para cada estudiante o pareja, pero en ciertos momentos debió ampliarse este tiempo. En estas sesiones se hacía lo siguiente:

- Primero se preguntaba qué dudas se tenían.
- Se revisaban los informes de valoración descritos anteriormente.
- Se hacían ejercicios para aclarar proposiciones.
- Entre las parejas y pequeños grupos se hacían preguntas.
- En todo momento se utilizaron las preguntas pedagógicas
- Se utilizó la herramienta de exportar las proposiciones de Cmap Tool, para evidenciar las congruencias e incongruencias, en caso necesario.
- Se entregaban las calificaciones de los mapas finales y se discutía esta calificación.

Este tipo de tutorías ayudó a retomar, en la clase regular, diversos contenidos. Se establecía un diálogo que permitía la validación de las proposiciones, así como la toma de conciencia metacognitiva. A continuación un ejemplo:

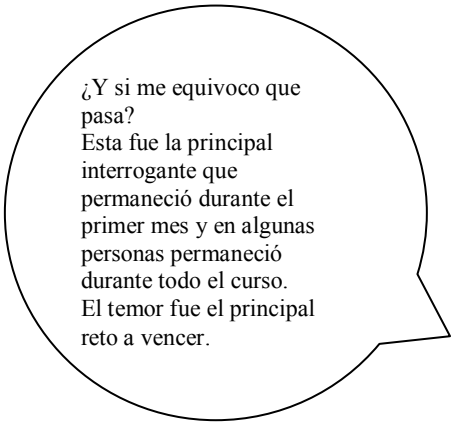
Docente: Tatiana, ¿qué relación puede establecer entre el concepto de Lectura convencional y Simbolización, que

usted puso en su mapa? Elabore una proposición con esos dos conceptos.

Estudiante: “La simbolización es necesaria para la lectura convencional”

Docente: Tatiana, ¿cómo se llama esa capacidad que usted acaba de utilizar?

Estudiante: acabo de interpretar y relacionar

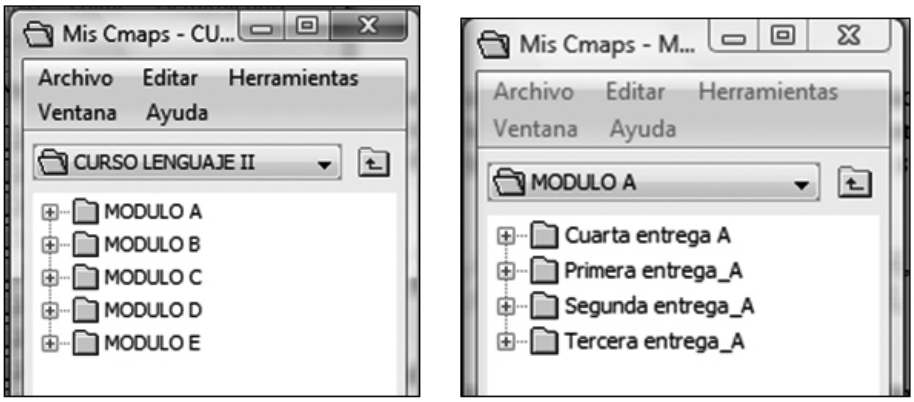


El registro de entrega de mapas conceptuales

Para llevar el control se organizaron dos tipos de registro: un registro de control: un registro impreso para el control de entrega de mapas, versiones, y observaciones a los mapas. A continuación un extracto de este registro.

Nombre estudiante	Entrega mapa A-1	Devolución con comentarios	Entrega mapa A-2	Devolución con comentarios	Entrega mapa A-final
Tatiana	✓	✓	✓	✓	✓
Gabriela	✓	✓	✓- **final**		
Yamil	✓	✓	✓- **final**		

El otro registro se organizó digitalmente mediante el programa “CmapTool”, el cual se visualizó así:



El instrumento de evaluación y calificación final

Además de todo el proceso de valoración que se realizó mediante la entrega de informes y tutorías, se requirió de un instrumento que cuantificara para la valoración de los mapas conceptuales. Entonces se definieron 9 criterios referidos a aspectos sobre gestión, organización y contenido en los mapas conceptuales, los cuales se utilizaron en un instrumento cuantificable. Estos criterios se intercalaban con cinco columnas correspondientes a los cinco mapas finales que se debían presentar, además se agregó en cada caso una escala numerada para calificar.

Del instrumento tenían copia tanto la docente como el estudiante. Este instrumento iba y venía cada vez que se calificaba un mapa en su versión final. Este instrumento de calificación se puede observar en la página siguiente.

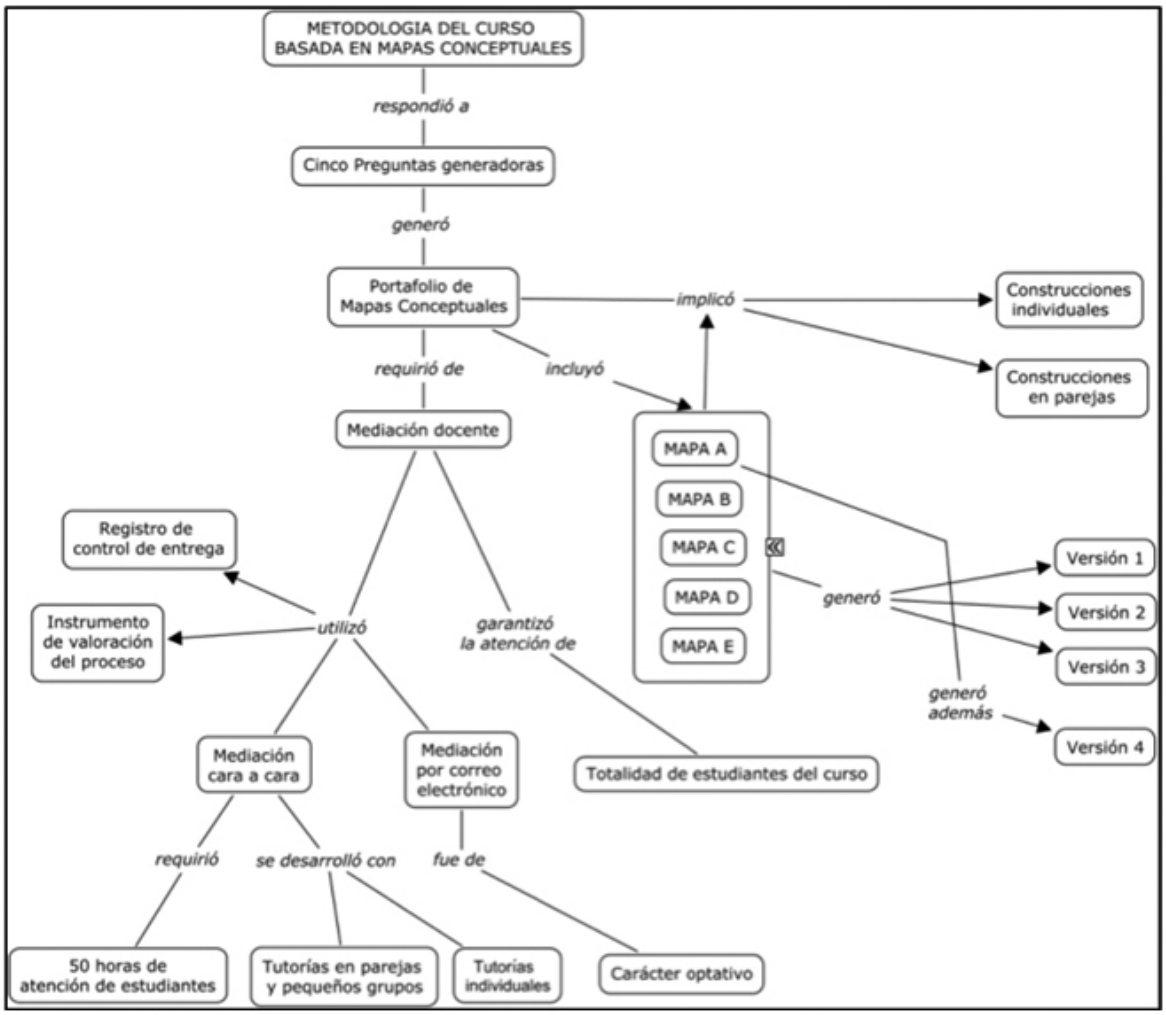


Figura 1. Síntesis del proceso metodológico para la elaboración y valoración de portafolios de mapas conceptuales. Mapa de elaboración propia

VALORACIÓN DE PORTAFOLIO DE MAPAS CONCEPTUALES (MC) 50 %

Nombre del/ de la estudiante_____ Porcentaje obtenido _____

Cada MC responde a una pregunta planteada en el programa de curso, entregado el primer día de clase. Por cuanto son 5 MC, cada uno tiene un valor de 9%, las aportaciones (producciones elaboradas en clase o extraclase), tienen un valor de 5 %.

Dado que la elaboración de MC son un proceso, cada MC debe demostrar un avance en el logro de capacidades, de tal manera que los criterios de valoración para cada mapa varían.

Primer mapa conceptual. Responde a la pregunta: ¿Cuál es la relación entre aprendizaje, pensamiento y lenguaje gráfico (lecto escritura?

Segundo mapa conceptual. Responde a la pregunta:¿Cuàles son las capacidades que se necesitan durante el proceso de desarrollo del grafismo/lecto-escritura?

Tercer mapa. Responde a la pregunta: ¿En qué consisten las etapas del desarrollo gráfico y lectura, en el nivel de preescolar?

Cuarto mapa conceptual. Responde a la pregunta: ¿En qué consiste la didáctica del desarrollo lecto-escrito/gráfico, a utilizar en el nivel preescolar?

Quinto mapa conceptual. Responde a la pregunta: ¿En qué consisten los métodos de lecto-escritura que se utilizan en Costa Rica?

No de mapa	1	2	3	4	5
Criterios de valoración					
a. Demuestra un proceso de mejoramiento al reelaborar el mapa varias veces.	0 – 0. 5 - 1 – 1.5 – 2 – 2.5 - 3	0 – 0. 5 - 1 – 1.5	0 – 0. 5 - 1	0 – 0. 5	----
b. Ha aprovechado el espacio de atención que ofrece la profesora para plantear dudas y reflexionar sobre el propio proceso	0 – 0.5 – 1	0 – 0. 5	0 – 0. 5	0 – 0. 5	----
c. Logra establecer premisas claras y coherentes	0- 0.5 - 1	0 – 0. 5 - 1 – 1.5	0 – 0. 5 - 1 – 1.5	0 – 0. 5 - 1	0 – 0. 5 - 1
d. Organiza el mapa de manera jerárquica (de lo general a particular, sin repetir conceptos) o ideas)	0 – 0.5 - 1	0 – 0. 5 - 1	0 – 0. 5 - 1	0 – 0. 5 - 1	0 – 0. 5 – 1
e. Incorpora conceptos e ideas relevantes para responder a la pregunta.	0- 0.5 - 1	0 – 0. 5 - 1	0 – 0. 5 - 1	0 – 0. 5 - 1	0 – 0. 5 - 1
f. Establece relaciones (a nivel horizontal y vertical) claras y coherentes entre los conceptos	0- 0.5 - 1	0 – 0. 5 - 1 – 1.5	0 – 0. 5 - 1 – 1.5	0 – 0. 5 – 1 – 1.5	0 – 0. 5 - 1 – 1.5
g. El mapa en su totalidad logra responder a la pregunta	0- 0.5 - 1	0 – 0. 5 - 1 – 1.5	0 – 0. 5 - 1 – 1.5	0 – 0. 5 – 1 – 1.5	0 – 0. 5 - 1 – 1.5
h. Establece relaciones propias a partir de las ideas generales.		0 – 0.5	0 – 0.5 - 1	0 – 0. 5 - 1	0 – 0. 5 - 1 – 1.5
i. Evidencia capacidades de interpretación, análisis y síntesis.				0 – 0. 5 - 1	0 – 0. 5 - 1 – 1.5
TOTAL	9 /	9/	9/	9/	9/

Producciones en clase o extraclase (5%) : Se incorporan a un mínimo de 5 aportaciones. 0 – 1 – 2 –3 –4 –5

5 Algunos resultados

Resultados cuantificables

El portafolio de mapas conceptuales tenía un 50 % del valor del curso, el porcentaje menor registrado fue de 38,25 % y el mayor de 50 %, el promedio rondó el 37 %. En total se revisaron al menos 172 mapas conceptuales, ya que entre versión y versión, también se revisaban otros. La siguiente tabla muestra, a manera de resumen, la frecuencia de entrega de mapas conceptuales, revisados de manera individual y en parejas:

Mapa	Mapa A				Mapa B		Mapas C		Mapa D	
Tipo de entrega	**1**	**2**	**3**	**4**	**1**	**2**	**1**	**2**	**1**	**2**
Individual	27	15	16	2	18	15	16	6**	15*	1
En parejas	0	0	0	0	5	2	6	3	5	1
Totales (personas)	27	15	16	2	**28**	17	**28**	12	**25**	2

* Agregaron elementos adicionales: archivos, imágenes.

De la tabla anterior se obseva que el primer mapa fue el que requirió de más versiones, lo cual es compresible, dado que era el primero ser construido. Para los siguientes sólo se entregaron de una o dos versiones. También es importante destacar que las personas que iniciaron los mapas en parejas, a partir del mapa B, se mantuvieron trabajando de

esa manera.

Resultados no cuantificables

Todas las estudiantes lograron mejoramiento en los mapas propuestos, ya fuera para ampliar, corregir conceptos proposiciones. Al lado derecho se muestra un ejemplo de mapa inicial y posteriomente una versión de mapa mejorado.

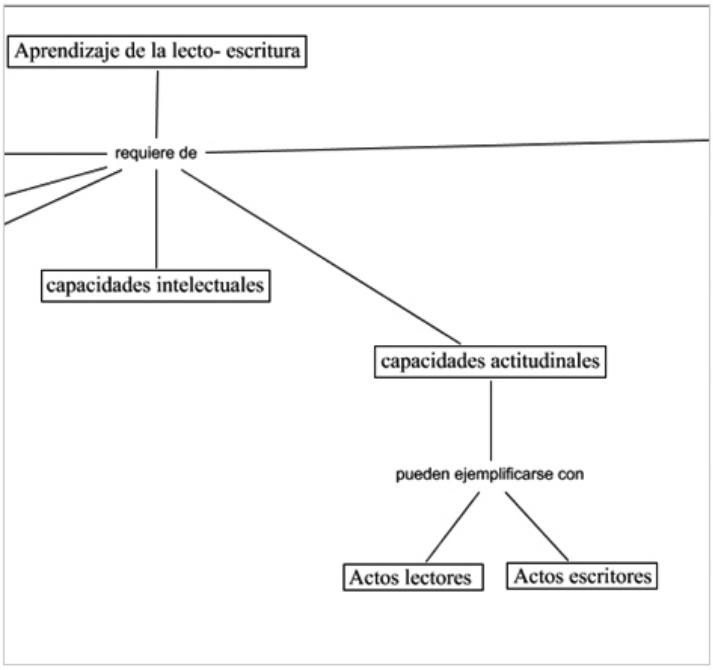


Figura 2. Karen. Mapa A, correspondiente a la primera pregunta. Primera versión (extracto)

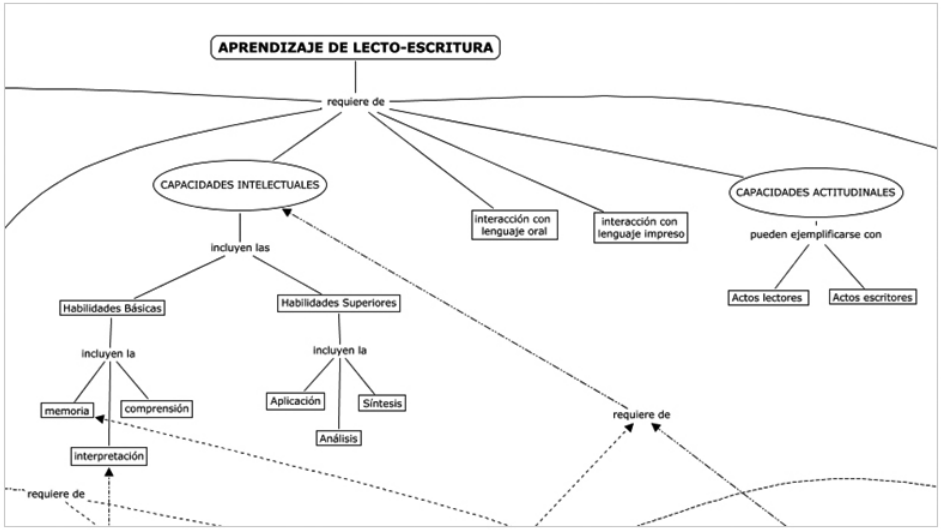


Figura 3. Karen. Mapa correspondiente a la primera pregunta. Segunda versión (extracto)

6 Consideraciones finales

Esta experiencia sobre el desarrollo de portafolios de mapas conceptuales muy provechoso evidencia logros, pero también limitaciones. Entre los logros, destacan al menos cuatro aspectos:

- El rescate del proceso de aprendizaje por parte de las estudiantes, además de la producción final.
- El papel mediador del docente, ofrece una oportunidad para un aprendizaje más personal.
- La definición de unos criterios de evaluación, coherentes con el proceso de aprendizaje, que si bien no pueden ser generalizables pueden servir de insumos a otros docentes que deseen incursionar en la evaluación utilizando mapas conceptuales.
- La construcción de un instrumento de calificación que de igual manera puede servir de insumos a otros docentes.

Entre las limitaciones y recomendaciones se encuentran el alto costo de tiempo en asumir la revisión de tantos mapas conceptuales, unido al tiempo extra en la atención de estudiantes. En este sentido sería deseable el trabajo en línea, más sin embargo no siempre las estudiantes cuentan con acceso a internet de manera permanente. Para una segunda oportunidad lo más aconsejable sería disminuir la cantidad de mapas conceptuales.

Como conclusión general, se logra ver el acercamiento entre evaluación y aprendizaje, donde la evaluación se constituye en instrumento para la autorregulación del propio aprendizaje.

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EXPLORING THE LIMITS OF CONCEPT MAPPING: WHEN LANGUAGE TAKES OVER

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Abstract. This paper combines a critique of the underlying theories of concept mapping for university level learning and case study data from two students, one in Classics and one in Neuroscience. A shift from the cognitive perspectives of assimilation learning theory towards a more narrative and representational visualisation is described and used to foreground a more dialogic approach. The results and conclusions show how higher education learning research can be developed by focusing on students' changing understandings of their discipline. The analysis shows that theories and methods addressing language use provide richer learning data and a more explanatory account of understanding in an academic context.

1 Introduction

A number of papers have reported the use of Novak's concept-mapping method (Novak, 1998) to document knowledge-change in the disciplines of university learning. Shavelsen et al (2005), for example, provide concept-mapping data for learning in Science; Hay et al (2008) offer data in Medicine; Hay, Wells & Kinchin (2008) in Psychiatry; and Hay & Kinchin (2008) in Education and Business Studies. These reports are important because they help to throw light on the interplay between student prior knowledge and the sense that is made of teaching (review by Hay et al, 2008). But as Hay (2008) explains, the concept-mapping data of higher education needs to be treated with caution for several important reasons. First, Novak's concept-mapping method depends on certain rules of map construction that shape a-priori what can and cannot be said using concept-mapping. Second, and related to this first concern, the epistemological commitments of students' concept-maps are often left unstated when concept-mapping is the only mode of expression (Kress, 2003). Third, the theoretical position of concept-mapping is grounded in Ausubel's theory of assimilation learning (1963; Ausubel et al, 1978). This makes concept-mapping suited to just those university disciplines with a corresponding theory of knowledge, whilst also predisposing the interpretation of concept-mapping data towards particular educational theories (like Vygotsky's (1986) model of learning in the zone of proximal development), because it presupposes that learning is essentially cognitive rather than being also a function of the social imagination (Hay, 2008). Exploring the utility of a broader use of concept-mapping for the facilitation of leaning at the university level is part of the purpose of this paper.

Most previous uses of Novak's concept-mapping method depend on using the technique as "windows into the mind" (Shavelsen et al., 2005, p. 413). This is because concept-mapping is essentially a method of cognitive psychology and it was first developed to test for conceptions (and misconceptions) from a cognitive standpoint (Novak & Gowin, 1984). Thus, for example, Hay et al (2008) describe concept-mapping as a part of meaningful teaching design: first, as a means of ensuring that the methods and approaches of teaching are grounded in student prior knowledge and, second, as a way of documenting whether or not misconceptions are corrected through teaching. Both of these applications are consequences of Novak's prerequisites for meaningful learning:

1. Relevant prior knowledge: That is, the learner must know some information that relates to the new information to be learned in some nontrivial way;
2. Meaningful material: That is, the knowledge to be learned must be relevant to other knowledge and must contain significant concepts and propositions;
3. The learner must choose to learn meaningfully. That is, the learner must consciously and deliberately choose to relate new knowledge to knowledge the learner already knows in some nontrivial way (1998, p.19).

But these approaches also depend on using mapping only as a 'test' for knowledge, not as means of teaching and learning per se. In this paper, concept maps are used in discipline-based university settings. The consequences of mapping high-level thinking are analysed and the widening use of images and language in the maps is explored.

2 Concept mapping: theory and origins

In the 1970s and 80s Novak and his colleagues developed a new method for the analysis of school students' spoken accounts of the science subjects they were learning (see Novak & Gowin, 1984; Novak & Mussonda, 1991; Novak & Symington, 1982). Briefly, the original concept-mapping method allowed researchers to convert the interview transcripts of student subjects into simple graphic structures comprising concept labels and propositions. These maps could then be compared in the longitudinal direction of the subjects' learning allowing comparison of changing cognitive organisation, content and the occurrence of misconceptions (Novak, 1998; Novak & Mussonda, 1991). Since the approach was grounded in a theory of assimilation that took the integrative reconciliation of new knowledge (or the lack of it) to be a measure of change (after Ausubel, 1963; 2000), so it allowed empirical analysis of the quality of learning (Hay, 2007; Novak, 1998).

2.1 Using concept-mapping in higher education

Novak's concept-mapping method has been used to document the trajectories of university student learning, but has previously focused on using maps from the traditional perspectives of cognitive psychology. Kinchin et al (2000) explain this theoretical positioning more fully. These authors draw on the work of Halford (1993) to show that concept-mapping is a means to make explicit an internal representation or a mental model that reflects the structure of a concept in mind. However, concept-maps, while they generally entail a spatial arrangement of words, do not include visual images constructed by the map author. Of course, many modern concept-mapping technologies do make use of images and graphics or symbols; but these are almost invariably used to illustrate a map after construction, rather than acknowledging that the act of constituting the image-form is at least as significant as making a map using concept labels (Kress & van Leuwen, 2001). Thus the problems of concept-mapping for higher education are that: 1) the method does not fully acknowledge that interactions between mind and language (or whatever form of expression can be seen to constitute the communicative act) are mediated through various symbolic structures, only some of which might be accommodated by the concept-mapping method (Hay, 2008); 2) that without denying that knowledge is somehow patterned in mind, nevertheless, concepts are rather more malleable, vicariously distributed, conditional and tentative in the very process of 'language' use (Vosniadou, 2007); and 3) finally, by taking the essentially cognitive stance to begin with, traditional concept-mapping theory does not easily accommodate the multiple perspectives encountered in university settings (e.g. primary texts, secondary analysis, teachers' views and students' changing understandings over time).

These concerns would remain relatively inconsequential if concept-mapping were still being used exclusively to code the more natural speech acts of interview subjects. But since the original publication of Novak & Mussonda (1991), most concept-mapping studies report the method as a mode of self-expression. This transposition has never been accompanied by any substantial renegotiation of concept-mapping theory, but the shift is likely to be particularly problematic as one also moves from schools to higher learning settings, where discourse becomes increasingly specialised (Lea & Street, 1998) and where learning depends less on acquiring any given knowledge-content and more on the use and function of narrative (Bruner, 2002; 2006; Hounsell & Anderson, 2009; Mertz, 2007).

This more conversational view of concept-mapping may be already suggested in several concept-mapping studies. Kinchin (2000a, b) shows that students offer different explanations towards different addressees (a parent versus a teacher, for example), suggesting that indeed the issue of context enters in already, as part of the mapping act. Nevertheless, the ease with which concept-mapping practice can include plural, even contradictory, explanations suggests that reframing concept-mapping theory is necessary to make sense of some of the data that the method can offer already. But now the question of a language of mapping becomes even more pressing since, if we want to take concept-mapping further, the question becomes one of what can, and what cannot, be spoken about in concept-maps.

2.2 The conversations of disciplinary inquiry

The issue of correspondence between the logic and affordance of different representational modes is developed by Kress (e.g. 2003), and it coincides with another strand of the higher education literature that includes the notion of 'disciplinary ways of thinking and practising' (e.g. Hounsell, & McCune, 2002; Hounsell & Anderson, 2009; Mertz,

2007; Vosniadou, 2007). The interdependence of disciplinary thought and speech is developed in Bruner's writing about the narrative self (2006) and it explains why the learning of any discipline is much more than learning its 'facts' and information (or its 'concepts').

For Bruner (ibid.) the issue of understanding constituted in language goes beyond knowledge and its organisation: all of utterance is important to shaping the ways that disciplinary subjects are both thought of and used, and thus also to how academics and professionals use language in their service to others. While Bruner tends to focus of the vocational professions, similar issues of literacy pertain to the academic disciplines and their propensity for inquiry. In Bioscience, for example, research data often needs to be depicted graphically before it can be understood and many of the key hypotheses of biology are actually constituted in visual images (e.g. Fischer's Lock and Key Hypothesis [Fischer, 1894], Barker's structural model of the neurone [Barker, 1899] and the double helix structure of DNA [Watson & Crick, 1953] being just a few of many examples). Learning to read and write in images is therefore central to becoming a biologist (Hounsell & Anderson, 2009), just as the narrative is essential in developing understanding in Classics. So for the purpose of using concept-mapping at the university level, what is important is being able to include this wider range of representational forms, not just because this allows more to be said, but also because, otherwise, concept-mapping cannot be a means of learning from the whole of narrative. To further explore these issues, concept maps made in university settings in two different disciplines are explored.

3 Methodology

To test and develop a broad approach to the visualisation of understanding, four detailed longitudinal studies were carried out, each with a small cohort of learners in History, Classics, Bioscience and Medicine. These disciplines were chosen to represent a broad spectrum of higher education, but the focus of the work was not to extract generality, nor to be able to compare work in different disciplines; rather the intention was to document the trajectories of representational form and voice that the students would use as individual speakers of their subjects of inquiry. Although the broader scope of the work underpins some of the approaches to analysis, the data are too large for the purpose of this paper and the focus is on just two of the individual trajectories, one from a student in Classics and another from Neuroscience.

3.1 Data from maps in classics

Concept mapping was used to collect data to assess students' learning experiences through the duration of a university level course in the humanities. In this way, concept mapping was used as both a research and pedagogical tool. Twenty students in a Classics class were asked to create concept maps of the topic of the course: "The impact of Greek literature and culture on the Roman world." Students were given a brief tutorial on concept mapping at the beginning of the course. The maps were created at three points in the course. The first was made at the beginning of the course, prior to the commencement of teaching. The second map was made at the mid-point of the course, and the third map was made at the end of the course. Participation was voluntary and the maps were not used in their formal assessment of the course. The sequenced maps done by the students are discussed below, with an example of one student's maps presented to highlight the variations in the maps during the course.

3.2 Data from maps in neuroscience

A programme of educational research was undertaken to test the impacts of teaching in a third-year module for "Developmental Neurobiology", in what for most students is their final undergraduate year. The work was done using concept-mapping before, during, and after, the taught programme and a subsequent analysis of the students' knowledge structures was carried out using the more traditional approaches to concept-map. That work is reported elsewhere (e.g. Wingate et al, 2007), but the study was repeated with a new student cohort, this time asking for volunteers who would be willing to share in a much more detailed programme of research. This entailed the development and practice of more varied representational forms than concept-mapping traditionally allows. Four students agreed to take part and the data presented here was from one of students. These two students also took part in regular conversational interviews during the taught module, in the second semester of laboratory project work afterwards, during the exams

revision period, and once their final results had been published.

4 Data

In the data and discussion that follows, the aim is to show how methods that focus on developing and recording learning trajectories in some very different ways to the university learning trajectories previously shown using concept-mapping (e.g. Shavelson et al, 2005; Hay, 2007; Hay et al, 2008). This is because method inevitably interacts with the types of data that it is possible to collect and interpret. Thus, while concept-mapping still has an important role to play in higher education learning research and in university teaching (by helping lecturers to document the direction of their students' learning outcomes), there must also be caution about what the data means, acknowledging that the interval changes in a person's cognitive map are functions of the method (and its theory) already. Likewise, caution is needed with the case study data here, particularly since it is derived from work with just two students, but it is nevertheless an important addition to the field precisely because it visualises learning from different perspectives.

4.1 Classics maps: Need for holistic understanding

Traditional concept mapping analysis and assessment methods, both qualitative and quantitative, are only valid for the first map that the student created at the beginning of the course (see Figure 1). The student's initial understanding of the course material (prior to the commencement of teaching) can be assessed under basic concept mapping metrics of hierarchy and propositional linkages. However, the student does not show a deep understanding of the relationships between the concepts, and furthermore the initial map shows a rather particulate view of the topic. This is seen in Figure 1 where the two main topics of discussion (Greek Culture and the Roman World) are not connected together.

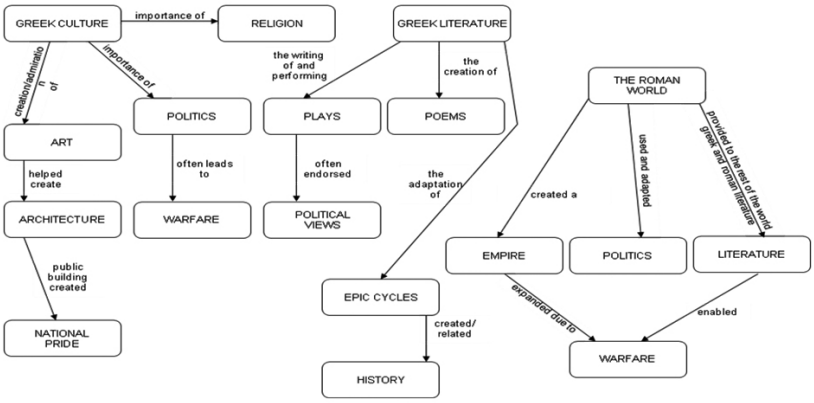


Figure 1. Prior-learning map in Classics

Once students progressed along in the course, their understanding of the concepts moved beyond the initial brief propositional statements that could be organized hierarchically. This is seen in Figure 2, where instead of linking concepts with a word or short phrase, the student often wrote long complete sentences to connect the concepts in the map. Furthermore, in another map, a student combined concept mapping with brief essays to explain the complicated relationship between the concepts. As the maps shown indicate, there was change from the first map to second, which was the case for all of the students. There was a move from a general, descriptive account of the subject matter to the development of personal understanding of the course. However, this understanding can only be seen when the construct of the map is analysed as a whole, rather than as a set of discreet linked concepts. The second case study delves into further issues of the limits of traditional concept mapping at the university level.

4.2 Neuroscience maps: The absence of relevant prior-knowledge

The role of prior knowledge is central to concept-mapping and attendant assimilation learning theory. But in all the interviews surrounding her work the student argued repeatedly that she had no relevant prior knowledge of the subject. When the form-shape of her understanding did eventually appear (see Figure 3), it also coincided with the given images of the subject, but this coincidence was not direct; it was not a product of learning to draw and read the image of biological tissues, it was a lexical arrangement (not pictographic) in which the patterning of structure could be shown to be derived from a growing apprehension (emotional as well as cognitive) of the subject of inquiry. This is to say that, without ever trying to learn the forms given in her teaching, the student had begun to 'picture' and relate towards the subject directly, grasping the sense towards which all her different papers and lectures, between them, were pointing.

As we see: 1) her work was constituted originally, in a series of lexical shapes that were always unique; 2) its coincident pattern was implied by the form-shape drawn with words rather than ever being drawn directly; and 3) while the underlying form was often the biological one (suggesting recognizable anatomical structures or a temporal development processes), this was not always the case; sometimes it is more metaphorical imagery that patterned the student's words - giving rise to structure she described as: "an analogue of the subject"; or: "the shapes that I feel and remember because this is what I imagine it must be like inside the structures I am describing". Most importantly, however, all of the patterning of understanding arose in the process of repeated inter-textual reading. Essentially, the student grasps what it means to read in an academic fashion; understanding that the significance of a written text (or image) is not to be found in a simple and personal interpretation of its substance, but in its relation with other texts - so that understanding appears of its own volition when different texts are brought together.

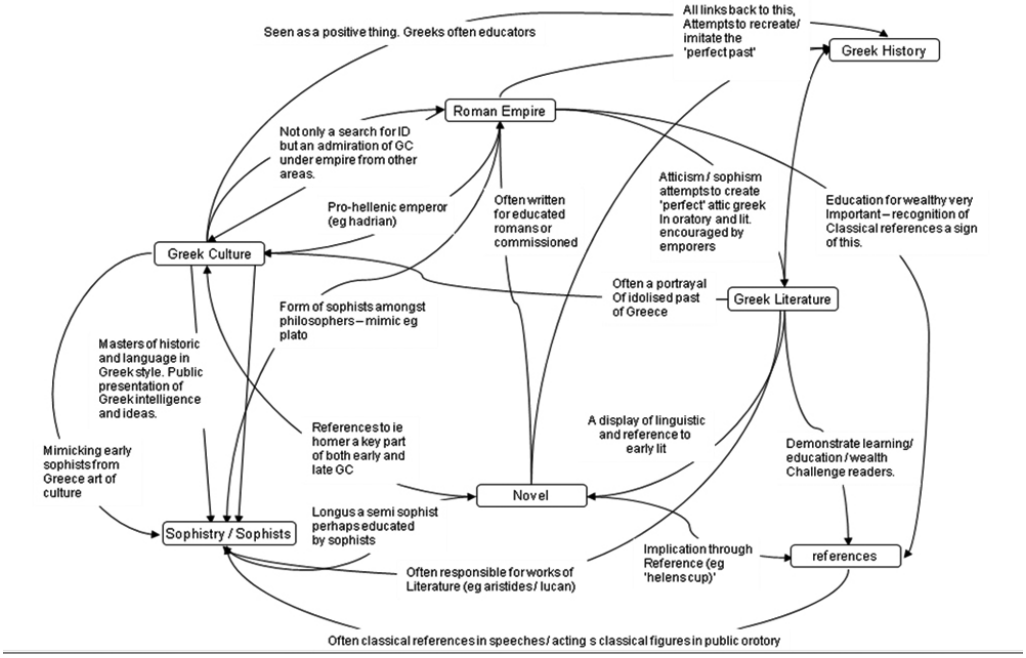


Figure 2. Development of understanding in Classics

5 Discussion

In the case study work, visualisation of understanding in a disciplinary way has been possible because of shifting the methodology from the theoretical frame of concept mapping towards analysis of communicative form. The issue is that methods like concept mapping require that learning is seen solely from a cognitive perspective, showing even a

continuous learning trajectory as an interval process, because the ways that concept-mapping theory construes learning are also interval. But at the same time, concept mapping offers no causal explanation of understanding: it only suggests that cognitive reorganisation can have different qualities (Hay, 2007) or that each map can be more or less correct when compared to the authorised structure of knowledge worked out already (Hay, 2008). Picture for example, how we might interpret the data if we had used concept mapping theory to locate them, and also if we had to do so without recourse to the students' spoken narratives. Then, the work of the neuroscience student in particular would be very difficult to explain, since what has actually been visualised here is a learning process rather than successive stages of development towards a pre-determined knowledge structure.

Both of the students' work is more continuous than concept-mapping theory implies. It is not the grasp of new 'concepts' that makes one map different from another but, in the discourse, the 'concept' (idea) and the narrative function are inseparable, and understanding arises as insight. Even, we might add, all the forms of the subject already include more than their knowledge structure: they encompass the conditionality of the subject and the positions of their respective speaker/authors. All the conditionalities of inquiry (into a subject that is still not fully known to science) are represented too, so that understanding what is still to be discovered is also potential in each representation. All of this accrues as understanding inter-textually; none of the meanings of form can be given directly, excepting that the form already comprises clues for reading in its semiotic function (Kress, 2003). Using language in discourse is always meaningful (Kress, 2003), because use implies participation in meaning-making (Wegerif, 2007). If learning is viewed from the cognitive perspective of concept-mapping then the continuum from rote to meaningful learning quality may be relevant, but in a university context, our attention shifts towards the understanding itself; the quality of the reading/writing that is design (Kress, 2000; Lillis, 2003) and the advice that lecturers can give to help their students 'read' in increasingly sophisticated ways.

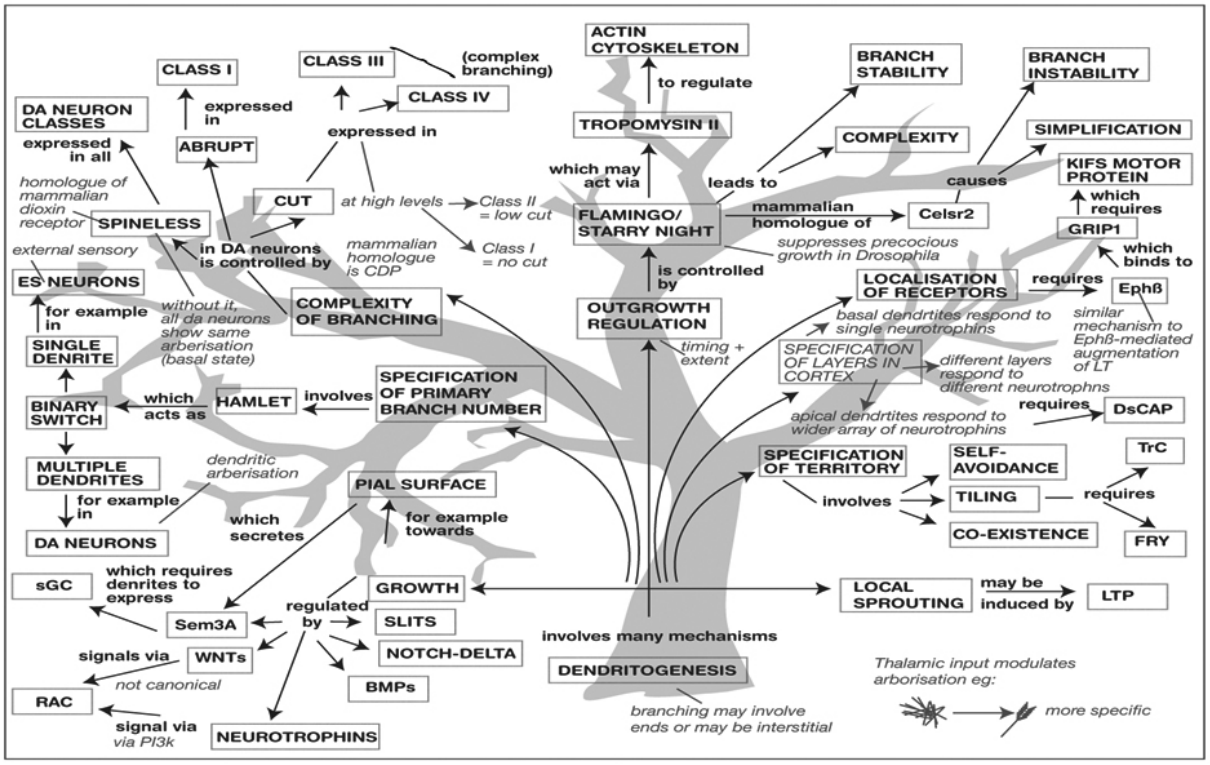


Figure 3. Map from Neuroscience

As a result, the data and the theoretical development presented here, while they are specific to two different university learning contexts, nevertheless they challenge the relevance of some of the central assumptions of concept-mapping and associated assimilation learning theory: 1) the learner's prior knowledge has not been shown to always be the precondition of developing understanding; rather learning for understanding is explained in terms of reading (including a view of writing or drawing as 'reading' also); 2) the relevance of integrative assimilation among new and old knowledge structures is also questioned by data; and 3) related to this, the meaningful or rote learning model is problematic because it does not account for the meaning of representation in the course of learning. None of this is criticism of concept mapping however, a method that remains relevant for use from a cognitive perspective, but it does suggest that assimilation theory ignores the richness of 'learning' and therefore fails also to explain understanding as a process.

6 Conclusions

This paper has shown how the methods of concept mapping, originally developed for the longitudinal documentation of cognitive change can be re-framed theoretically, and in practice, to record the successive and complex forms that are used in university learning. The empirical data illustrates the extension of two learners' processes of understanding. Two different types of learning approach have been explored. The learning trajectory of one student (Figures 1 and 2) has been shown to comprise a developing literacy whereby material that is been read and taught to the student is mapped, but the need for language to specify relationships has shown limits of concept mapping. The work of the other (Figure 3) is more imaginative, including acknowledgement of context. The approach is also demonstrably relational and includes a multi-modal understanding of disciplinary knowledge. Rowland (2005) highlights the importance of relationship towards a discipline; despite the constraints of modern higher education teaching, these data show that this relationship is there to be found by undergraduates.

In both disciplines, there is reflection upon the topic as a whole which assimilation theory fails to capture. The method of concept mapping allows for the learning process to be made visible and provides snapshots of change; however, these maps show a constant development of narrative of understanding. Therefore, there is much reason to advocate for concept mapping with a different underlying principle than assimilation theory, which is non-hierarchical, not particulate, and not reducible to atomic parts but personally reflective and grounded in narrative. Although rules for creating and assessing concept maps may be valid and useful in some settings, these case studies illustrate that a broad assessment scheme is needed in disciplinary settings. As a research tool, concept mapping at this level of education shows the complexity of students' structuring and understanding of a course. The process of mapping can also be used as a pedagogical tool, but the purpose of mapping and the context of assessment need to be reconceptualised.

What is crucial to this new utility for concept mapping is removing the method from its original assimilationist framework and relocating it in the broader context of dialogic theory (Bakhtin, 1981, 1986; Wegerif, 2007, 2008). Thus the map can be seen as a place where public and private reflection meets and leads to 'ideas made personal.' This is quite a different approach from the traditional stance of concept mapping which assumes each map to be the prior-knowledge structure of another, as well as the vehicle for interpreting new knowledge (Ausubel, 1963). The dialogic approach lays much greater emphasis on the process of linking the public and personal to create a new understanding, which is rather more an issue of self-authorship (Baxter-Magolda, 2004) than assimilation of new knowledge. The attention that Novak and others draw towards the cross-links in an individual's knowledge-structure is important because it signals personal understanding, or creativity in the learning process (e.g. Novak & Gowin, 1984; Novak, 1998; Mintzes et al., 1999). But in order to explain how creative leaps occur and to help to promote them, the instructor needs to engage in the reflective and dialogic learning process.

A movement toward a dialogic perspective acknowledges that the concept map is the text itself, both for the purposes of learning research and for the development of students' personal understanding. In this way, the maps act as tool for feedback and formative assessment in the writing and revision process, rather than as an object for assessment in itself. As Kress (2003, p. 140) states, the movement is away from reading how "text tells the world" to how it "shows the world." This change opens up for the students' self in the learning process) because it invites participation in creation of meaning (Hermansen, 2005). This issue of personal engagement with knowledge is the one that speaks to all disciplinary inquiry as being a creative process, rather than closing it down from the personal perspective.

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IMPACTO DE RETROALIMENTACIÓN REMOTA A MAPAS CONCEPTUALES ELABORADOS POR ESTUDIANTES DEL PROYECTO CONÉCTATE

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Abstract. Resumen. El objetivo del presente estudio fue explorar el impacto de dar retroalimentación oportuna y relevante a mapas conceptuales de estudiantes, concretamente en su motivación por re-trabajar sus mapas para expresar una comprensión más profunda del tema tratado en los mismos. Al grupo experimental se le formularon preguntas pedagógicas mientras que al control se le hicieron comentarios "placebo". Los resultados muestran una mejora significativa en la calidad de los mapas conceptuales para los dos grupos; esto es, no se observó un efecto diferencial por la condición experimental. Esto apunta a que el efecto motivador fue igual para todos los estudiantes. Por otra parte, se encontraron diferencias significativas por actitud del docente. En particular, pareciera que un docente proactivo fue capaz de aprovechar la retroalimentación para ayudar a todos sus estudiantes a mejorar sus mapas, cosa que no lograron hacer con la misma efectividad sus colegas no proactivos.

1 Introducción

En el 2005 el Gobierno de Panamá puso en marcha Conéctate al Conocimiento (Tarté, 2006), un ambicioso proyecto educativo para transformar la educación en las escuelas primarias oficiales del país. Como principal instrumento pedagógico se utilizaron los mapas conceptuales, implementados en diversas modalidades. En su formato digital, se creaban mediante el programa CmapTools (Cañas, et al., 2004).

Un monitoreo realizado a lo largo del año escolar 2008 de mapas conceptuales elaborados por estudiantes (Miller et al., 2010) indicaba que el nivel topológico promedio (Cañas et al., 2006) de estos mapas era de 3 (en una escala de 0 – 6), esto es, mapas poco profundos y con ramificación media; mientras que la complejidad semántica (Miller & Cañas, 2008) era de un nivel muy bajo. Independientemente de estos resultados, sabíamos por informes y comentarios de los facilitadores encargados de las capacitaciones y seguimiento en las escuelas que la mayoría de los mapas de los estudiantes prácticamente no recibían retroalimentación ni eran re-trabajados.

Lo antes descrito no es una situación única en Panamá. Diferentes autores (p.ej., Cañas & Novak, 2006; Conlon, 2004) señalan que menudo los estudiantes sólo tienen una oportunidad de trabajar en sus mapas. Sin embargo, también se sabe que por lo regular se necesitan al menos tres iteraciones para lograr buenos mapas (Novak & Cañas, 2008). En el Modelo de Aprendizaje Centrado en Mapas Conceptuales propuesto por Cañas & Novak (2008), "el mapa conceptual evoluciona conforme el estudiante aprende, reflejando su mayor comprensión, y es a través de preguntas del docente, preguntas de los pares, o preguntas que el estudiante se hace a sí mismo, que el estudiante persigue un entendimiento más profundo el cual se refleja en su mapa."

Este estudio se propuso explorar el impacto que podía tener una intervención basada en preguntas pedagógicas (Chacón, 2006) sobre la evolución de mapas conceptuales de estudiantes y su motivación a seguirlos modificando.

2 Metodología

2.1. Intervención experimental y muestra

La intervención experimental consistía en aprovechar la capacidad de colaboración asincrónica del programa Cmap-

Tools para colocar anotaciones a los mapas vía remota, por medio del servidor de la escuela. Por ello, la elección de escuela estuvo determinada primero por contar con un Aula de Innovación (AI) equipada y una conexión a Internet confiable. En adición a las anotaciones, se contempló la posibilidad de que surgieran intercambios espontáneos entre investigadores y estudiantes, propiciados por la aparición de las anotaciones en los mapas. Por esta razón, en la elección de la escuela influyó también el contar con herramientas que permitiesen a los estudiantes comunicarse vía correo electrónico o chat con los investigadores. Al momento de planear el estudio, sólo una escuela del Proyecto contaba con esta capacidad instalada y funcional. Se escogió pues esta escuela, ubicada en un área urbana de la Ciudad de Panamá, con varios años de participación en Conéctate. Dicha escuela tenía otra ventaja: contaba con una coordinadora del AI muy comprometida con el Proyecto y muy anuente a apoyar nuestras investigaciones.

Se decidió trabajar con estudiantes de 5º grado, por considerar que éstos ya tendrían cierta familiaridad con los mapas conceptuales[1], con lo cual el énfasis de la intervención podría centrarse sobre el contenido de los mapas. En la escuela elegida había cuatro grupos de 5º grado. A fin de tener una muestra de mayor tamaño, y evitar hacer diferencias entre los estudiantes, se incluyeron en el estudio los cuatro grupos.

Por otra parte, contábamos con información sobre diferencias importantes entre el estilo de docencia de los 4 maestros involucrados. Esto nos llevó a definir la variable "actitud del docente" con dos niveles: proactivos, aquellos que daban muestras de un estilo más centrado en el estudiante, más flexible y más abiertos al uso de la tecnología en su labor; y no proactivos, aquellos más tradicionales, más rígidos, y menos inclinados al uso de la tecnología. Resultaba fundamental controlar esta variable, pues podía ser un factor de confusión. Por este motivo, la mitad de los estudiantes de cada grupo fueron asignados en forma aleatoria a los grupos experimental (GE) y la mitad restante al grupo control (GC). Los GE y GC resultaron ser de 55 y 53 estudiantes, respectivamente.

La intervención experimental consistía en proporcionar a los estudiantes del GE retroalimentación con preguntas que les permitiesen ampliar, mejorar o corregir el contenido de sus mapas. No obstante, dado que resultaba imposible aislar a los integrantes del GE y del GC para evitar comentarios entre ellos, y considerando que de darse dichos comentarios podrían afectar el ánimo de los estudiantes del GC, decidimos que era necesario proveerle a este grupo algún tipo de retroalimentación también. Llegamos así a la idea de "anotaciones placebo", es decir, anotaciones en las que sólo se hacían comentarios generales sobre el aspecto del mapa, o se animaba al estudiante a seguir adelante; por ejemplo interjecciones como "me gusta tu mapa", "sigue así", "elegiste bonitos colores", etc. Eran expresiones de aliento, más que preguntas; lo importante era no aportar ningún elemento que se pudiese vincular directamente con una mejora en la topología o en la semántica del mapa conceptual. En este sentido la intervención pretendía ser "neutra". Dado que los estudiantes no sabían que eran parte de un experimento[2], no había motivo para sospechar de diferencias fundamentales en la naturaleza de la retroalimentación recibían.

Respecto al equipo investigador, éste los conformaban cinco personas, tres facilitadores y dos colaboradores del Proyecto Conéctate. A los investigadores se les asignó aleatoriamente dos conjuntos mutuamente excluyentes (sin intersección) de alumnos, llamémosles A y B: cada investigador debía evaluar el mapa inicial y todas sus modificaciones de su grupo A de estudiantes; a los estudiantes de su grupo B les proporcionaría retroalimentación, preguntas o comentarios placebo, según si pertenecían al GE o GC, respectivamente. Ningún investigador, salvo el responsable del estudio tenía acceso a la distribución de estudiantes, ni a las evaluaciones que de los mapas se iban haciendo. No obstante, en realidad no se trata de un formato "ciego" ya que en principio con ver las anotaciones se podía saber qué tipo de retroalimentación estaba recibiendo un alumno[3]. Lo que no podía saberse era el docente.

2.2. Tópico y herramientas de medición

A fin de que nuestra investigación fuese percibida como un aporte a su labor docente, la selección del tópico para los mapas conceptuales se dejó en manos de los docentes. Se les pidió solamente que fuese un tema lo suficientemente amplio como para tratarlo a lo largo de las 10 semanas que duraría la intervención (todo el tercer bimestre). El tema que eligieron fue "Fuentes de Energía", el cual encajaba dentro del tópico general "La materia y la energía; sus in-

[1]En las escuelas participantes, se capacitaba a los docentes de 4º, 5º y 6º grado.
[2]De hecho, recibir las anotaciones fue una gran sorpresa para ellos.
[3]Para que fuese realmente ciego habría que haber hecho una copia de los mapas con las anotaciones borradas antes de dar los mapas a los evaluadores para su evaluación.

teracciones y cambios en la naturaleza" que estudiarían durante ese bimestre para la materia de Ciencias Naturales. La opinión de los investigadores era que este tema no daba para ser tratado durante todo un bimestre. No obstante, en vista de la necesidad de contar con el apoyo de los docentes, respetamos su decisión, e intentamos formular una pregunta de enfoque que invitara a desarrollar lo más posible el tema. La pregunta consensuada por el equipo investigador fue la siguiente: ¿Cómo podemos los seres humanos obtener la energía que necesitamos en nuestra vida diaria de una manera que sea sostenible en el tiempo y no dañe la naturaleza?

Las herramientas utilizadas para evaluar los mapas conceptuales fueron la taxonomía topológica (Cañas, et al., 2006) y la rúbrica de evaluación semántica (Miller & Cañas, 2008). Las evaluaciones topológica y semántica de los mapas iniciales se tomaron como referencia para medir el efecto de las intervenciones subsiguientes. Como método alternativo de medición de aprendizaje, concluido la intervención se creó un collage alusivo al tema de fuentes de energía en el que se incluyeron imágenes de todos los conceptos plasmados en los mapas de los estudiantes. Un mes después de la última revisión a los mapas, se visitó a los estudiantes (sin previo aviso) y a manera de "juego" se les pidió escribir todas las proposiciones sobre el tema de fuentes de energía que vinieran a su mente al ver el collage. Podían plasmar sus proposiciones en un MC o en texto. Adicionalmente, posterior a la última revisión a los mapas pero antes del ejercicio con el collage, se aplicó a los estudiantes un cuestionario para recoger las reacciones que les generó la experiencia.

2.3. Organización del trabajo

Según lo mencionado en párrafos anteriores, harían falta al menos tres intervenciones para lograr buenos mapas conceptuales. Por tal razón se estableció que habría tres intervenciones de retroalimentación por parte de los facilitadores, proveyéndoles así a los alumnos tres oportunidades para mejorar sus mapas. Las sesiones de trabajo de los estudiantes se realizarían una vez por semana, por 2 horas-clase consecutivas de 45 minutos cada una [4].

La distribución del trabajo a lo largo de las 10 semanas del bimestre se hizo como sigue: durante la semana 1 los docentes introdujeron el tema a sus estudiantes y en la semana 2 éstos construyeron su mapa inicial. La evaluación y retroalimentación de los mapas se realizó en la semana 3. Luego, en las semanas pares (4, 6, y 8) los estudiantes hicieron revisiones a sus mapas, y en las impares (5, 7, y 9), mientras unos investigadores evaluaron los mapas, otros colocaron las anotaciones. La idea tras esta distribución – con una semana de por medio entre una sesión de re-trabajo y otra – era darles tiempo a los estudiantes de buscar información, entender mejor el tema, y mejorar sus mapas en la próxima sesión de re-trabajo. También permitió a los docentes utilizar el AI en la semana intermedia para trabajar otros temas que estuvieran dando en clase, si así lo deseaban.

3 Resultados

En esta sección presentamos los resultados de la intervención. Se analiza primero la comparabilidad de los grupos; luego se presentan las evaluaciones topológicas y semánticas de los mapas; seguidamente se examinan las respuestas del cuestionario llenado por los estudiantes; y se concluye con los resultados de la evaluación mediante el collage.

3.1. Comparabilidad de los grupos experimental y control

La aleatorización de los grupos experimental y control resultó en dos grupos inicialmente comparables tanto en lo topológico como en lo semántico. Infortunadamente, un ausentismo importante entre los estudiantes, aunado al requerimiento de cuatro sesiones de trabajo en el mapa (la creación del original y las tres revisiones), resultó en una gran merma de participantes: de los 108 estudiantes inicialmente comprendidos en el estudio, sólo 20 – 11 en el GE y 9 en el GC – cumplieron a cabalidad con la intervención. Esta situación, además de reducir drásticamente la muestra, introdujo un potencial sesgo de selección. Por suerte, a pesar de la reducción, la comparabilidad de los grupos se mantuvo, como puede verse en la Tabla 1.

[4]Esto correspondía al tiempo semanal de trabajo en el aula de innovación especificado por la escuela.

GRUPO	Nivel Topológico			Nivel Semántico		
	Original	3ª revisión		Original	3ª revisión	
GE (n = 11)	3.0 (0.6)	3.8 (1.1)	*P = 0.00*	1.5 (0.5)	2.3 (0.8)	*P = 0.01*
GC (n = 9)	2.9 (0.3)	3.8 (0.8)	*P =0.02*	2.0 (0.3)	2.3 (0.7)	*P =0.20*
Probabilidad	*P = 0.64*	*P = 0.93*		*P = 0.13*	*P = 0.86*	

Tabla 1. Niveles topológico y semántico del GE y GC en el mapa original y en 3ª revisión para aquellos estudiantes que completaron todas las revisiones.

3.2. Análisis topológico y semántico: impacto de la intervención

Hemos dicho que la condición experimental consistía en dar retroalimentación en forma de preguntas diseñadas para que los estudiantes corrigieran, profundizaran, y/o ampliaran sus mapas conceptuales; por su parte, la condición de control involucraba comentarios neutros en el sentido de que no aportaban elementos específicos para mejorar la estructura y/o contenido de los mapas. A fin de comparar el impacto de la intervención, se comparó el mapa original, punto de referencia obligado, con la 3ª revisión, o versión final, del mapa. En la Tabla 1 se muestran los resultados. Como puede apreciarse, no se encontraron diferencias significativas en el nivel topológico y semántico de los GE y GC; después de la intervención los dos grupos resultaron prácticamente indistinguibles.

Lo que se observa, sin embargo, es un incremento significativo en lo topológico entre el mapa original y la revisión final en cada grupo. El cambio es de casi un nivel, desde mapas estructuralmente pobres hasta mapas aceptables. En la parte semántica, se dio un aumento significativo en el grupo experimental, de una calidad de contenido muy bajo a bajo; en el control el cambio no fue significativo. Estos resultados apuntan a que, en comparación con los comentarios placebo, la formulación de preguntas para estimular el cuestionamiento, la reflexión, y la búsqueda de información, no propició diferencias de consideración en cuanto a estructura; en lo semántico se detecta un mejor desempeño del GE el cual superó la desventaja con que empezó respecto al control.

En otro punto, la correlación entre el número de visitas al AI y la calidad topológica y semántica de los mapas resultó negativa; más negativa para el grupo control que para el experimental. Finalmente, es importante resaltar que la prueba de ANOVA no arrojó diferencias entre las evaluaciones topológicas de los 5 investigadores que participaron.

3.2.1. Efecto de la actitud del docente

En el análisis anterior no se tomó en cuenta la actitud docente, la cual sabemos puede constituir un factor de confusión, tanto a favor como en contra de la intervención. A continuación consideramos esta variable.

Inicialmente, habíamos clasificado dos docentes como proactivos y dos como no proactivos. Sin embargo, en el curso del experimento nos pudimos percatar que un docente clasificado como proactivo no resultó serlo tanto; además, se ausentó de un gran número de clases. Por esta razón, se hizo una reclasificación agrupando a este docente junto con los dos maestros no proactivos, quedando sólo un docente en la categoría de proactivos. Por otra parte, para este análisis decidimos ampliar la muestra incluyendo a todos aquellos estudiantes cuyos mapas tuvieron "al menos una revisión", con el fin de poder observar mejor y con mayor confiabilidad el efecto de la actitud del docente, en caso de haberlo. Obtuvimos una muestra de 59 estudiantes, de los que 19 eran del docente proactivo y los 40 restantes de los tres no proactivos. El punto de interés era si, controlando la actitud del docente, se detecta alguna diferencia entre los grupos experimental y control.

Encontramos que en el primer mapa, había una diferencia significativa entre los estudiantes del docente proactivo respecto a los de los otros: los primeros tenían un nivel topológico de 2.9 vs. 2.4 de los segundos (P = 0.04); esta diferencia se volvió más pronunciada en el mapa final, 3.8 vs. 2.6 (P = 0.00). Por otro lado, en la parte de contenido no se

encontró diferencia en el mapa inicial, pero en el final apareció una diferencia: 2.3 vs. 1.7 (P = 0.01), para estudiantes del docente proactivo y los no proactivos, respectivamente.

Comparando GE con GC para los dos tipos de docente tenemos que, en el mapa inicial no detectamos diferencias, ni topológicas ni semánticas, entre estudiantes del GE y GC para ninguno de los tipos de docente; los grupos eran comparables. Esta misma situación se repitió en el mapa final. Concluimos entonces que la intervención mediante preguntas versus comentarios placebo no mostró un efecto diferencial para ningún tipo de docente (Tablas 2 y 3).

Estos resultados corroboran los datos de la sección anterior (Tabla 1) que indican que, independientemente del tipo de retroalimentación recibida, cuando los alumnos tienen más de una oportunidad de trabajar en sus mapas estos son capaces de aumentar la complejidad, estructural y semántica, de los mismos. Estos datos son coincidentes a lo planteado por Cañas y Novak (2008).

Docente Proactivo	Nivel Topológico		Nivel Semántico	
	Original	Final	Original	Final
GE (n = 10)	3.1 (0.6)	3.9 (0.7)	1.5 (0.5)	2.3 (0.8)
GC (n = 9)	2.8 (0.8)	3.8 (1.2)	1.7 (0.7)	2.3 (0.7)
Probabilidad	P = 0.33	P = 0.79	P = 0.57	P = 0.93

Tabla 2. En la categoría de docente proactivo, diferencias en nivel topológico y semántico entre GE y GC en mapa original y 3ª revisión. Todas las diferencias son no significativas.

Docentes no Proactivos	Nivel Topológico		Nivel Semántico	
	Original	Final	Original	Final
GE (n = 19)	2.5 (1.2)	2.8 (1.3)	1.3 (0.7)	1.7 (1.0)
GC (n = 21)	2.2 (1.1)	2.3 (1.1)	1.4 (1.0)	1.6 (1.0)
Probabilidad	P = 0.52	P = 0.16	P = 0.57	P = 0.84

Tabla 3. En la categoría de docente no proactivo, diferencias en nivel topológico y semántico entre GE y GC en mapa original y 3ª revisión. Todas las diferencias son no significativas.

3.3. Cuestionario post-intervención

A modo de complemento se aplicó a los estudiantes un cuestionario post-intervención que consistió de 7 preguntas con opciones propuestas, pero con posibilidad de agregar respuestas no ofrecidas entre las opciones. Se recogieron 87 cuestionarios, de los cuales se descartaron 24 por presentar contradicciones como: 1) indicar no haber recibido anotaciones, pero responder como si las hubiese recibido; y 2) indicar haber recibido anotaciones, siendo un alumno que sabemos no las recibió. A continuación resumimos lo más destacado que se desprende del análisis del cuestionario.

En vista de que los estudiantes no sabían que estarían recibiendo anotaciones en sus mapas, nos interesaba particularmente su reacción a la aparición de las mismas. La reacción más común fue sentirse "contento" (39%), seguido de "sorprendido" (29%), y "orgulloso", "emocionado" y "nervioso" (todas con 18%). Algunos expresaron otras cosas como "asustado", "mi corazón me latió y volví a hacer el mapa", "miedo", "la primera vez un poco nervioso", "[me sentí] bien pero no sabía qué era", entre otros. Por circunstancias ajenas a nuestro control[5], algunos no recibieron anotaciones. Éstos expresaron cosas como: "me sentí mal" o "continué mi trabajo igual".

En respuesta a las anotaciones, las acciones más comunes tomadas por los estudiantes fueron "cambiar el mapa" (41%), "mostrar las anotaciones a un compañero" (30%), y "buscar ayuda del docente o CAI" (21%). Los estudiantes

consideraron que las anotaciones les fueron de utilidad en primer lugar para "ayudar a ampliar el mapa" (39%), en segundo lugar "sirvieron para aprender" (32%), y en tercer lugar "motivaron para seguir" (30%). En cuanto a re-trabajar sus mapas, las respuestas de los estudiantes corroboran lo antes mencionado; manifestaron que "les gustó" (32%), "les ayudó a comprender mejor el tema" (31%), y "les motivó a ir al AI". Entre los recursos de apoyo más utilizados para re-trabajar sus mapas destacan Internet (42%), y ayuda docente (33%). Finalmente, la experiencia despertó su interés en "el tema de la energía" (41%), "compartir conocimientos" (25%), "trabajar con mapas conceptuales" (24%), e "investigar en Internet" (20%).

A un mes de concluida la actividad, se aplicó – sin previo aviso a docentes o estudiantes – la evaluación mediante el collage. Los niños eran libres de responder de la manera en que quisieran, por lo que las respuestas se dieron en tres formatos: texto, mapa conceptual, y una combinación de ambos. Dada la diferencia de formatos, buscamos una unidad de medición que pudiese aplicarse a todas por igual. Llegamos así al esquema de considerar los siguientes cinco elementos: 1) número de conceptos relevantes, 2) total de ideas relevantes (no necesariamente correctas), 3) número de ideas completamente correctas, 4) número de ideas parcialmente correctas, y 5) número de ideas erróneas. Hablamos de "ideas" en vez de "proposiciones" ya que lo que en formato texto se incorpora dentro de una misma oración en un MC puede comprender varias proposiciones (figura 1); en realidad, se trata de una sola "idea", por lo que la contabilizamos una única vez.

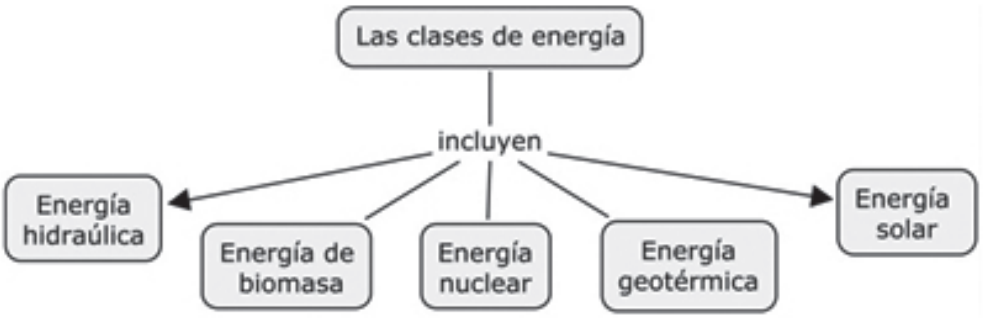


Figura 1. Mapa conceptual que comprende las cinco proposiciones contenidas en la oración "Hay diferentes clases de energía, como la energía hidráulica, energía solar, energía geotérmica, energía nuclear, energía de biomasa, etc.".

Los resultados del ejercicio con el collage para los grupos experimental y control no muestran diferencias significativas entre los grupos para ninguna de las variables, confirmando los resultados medidos con la taxonomía topológica y la rúbrica semántica.

Interesantemente, el collage tampoco reveló diferencias entre los que indicaron en su cuestionario que si recibieron anotaciones y los que no, ni tampoco entre los que dijeron que modificaron su mapa y los que no; las únicas diferencias que detectamos con el collage estaban asociadas a la actitud del docente, todas a favor del docente proactivo, como puede verse en la Tabla 5.

Variable	Docente proactivo (n = 16)	Docente no proactivo (n = 34)	Probabilidad
Conceptos	21.2 (7.9)	10.9 (6.2)	P = 0.00
Ideas relevantes (total)	12.6 (5.9)	4.7 (3.5)	P = 0.00
Ideas correctas	9.7 (6.3)	3.5 (3.0)	P = 0.00
Ideas parcialmente correctas	1.9 (1.7)	0.5 (0.8)	P = 0.00
Ideas erróneas	1.0 (1.3)	0.6 (0.9)	P = 0.24

Tabla 5. Comparación de evaluación mediante el collage para docente proactivo vs. no proactivos.

[5]No guardaron mapa, o lo guardaron localmente en vez de en el servidor.

A la hora de aplicar la evaluación mediante el collage, nos percatamos que algunos facilitadores animaban a los estudiantes a plasmar sus ideas, mientras que otros permanecieron más bien silenciosos después de haber dado las indicaciones iniciales; supusimos por tanto que el facilitador podía haber influido en los resultados. Se definió la variable "nivel de estímulo del facilitador" con dos categorías: alta y baja. Como sospechamos, esta variable incidió fuertemente en el desempeño de los estudiantes en el ejercicio con el collage, resultando diferencias altamente significativas en casi todas las variables medidas, teniendo mejor desempeño aquellos estudiantes que tuvieron un nivel alto de estimulo por parte del facilitador.

Finalmente se exploró la relación simultánea de estas dos variables categóricas independientes actitud del docente y estímulo del facilitador. Los resultados indican que ambas variables contribuyen significativamente a explicar los datos observados para las tres primeras variables.

Variable	Alto estímulo (n = 27)	Bajo estímulo (n = 23)	Probabilidad
Conceptos	19.7 (7.1)	7.7 (3.4)	P = 0.00
Ideas relevantes (total)	10.1 (5.9)	3.8 (3.0)	P = 0.00
Ideas correctas	7.7 (5.3)	3.0 (2.9)	P = 0.00
Ideas parcialmente correctas	1.5 (1.5)	0.3 (0.5)	P = 0.00
Ideas erróneas	1.0 (1.2)	0.5 (0.8)	P = 0.11

Tabla 6. Comparación de evaluación mediante el collage de estudiantes de que recibieron alto y bajo estímulo por parte de los facilitadores a la hora de aplicar la evaluación.

4 Discusión

A fin de que el uso educativo de los mapas conceptuales rinda los frutos que la herramienta es capaz de dar, se hace necesario desarrollar estrategias para propiciar que los mapas se re-trabajen. Una manera de lograrlo puede ser proporcionando retroalimentación oportuna y relevante en forma de preguntas que sirvan para ampliar, mejorar o corregir las ideas vertidas en el mapa. Hasta el momento, en el Proyecto Conéctate no se había explorado el impacto de dar este tipo de retroalimentación. Este estudio buscaba hacer precisamente eso.

El principal resultado del estudio fue que no pudo detectarse ningún efecto producto de la condición experimental. Hubo mejoras significativas de estructura y contenido entre el mapa inicial y el final, pero éstas se dieron por igual tanto en el GE como en el GC. Este resultado, quizá un poco sorprendente, puede significar varias cosas. Primero, pudiera ser que las "anotaciones placebo" del grupo control no fuesen tan "neutras" como imaginábamos. En un entorno en que los estudiantes no están acostumbrados a recibir retroalimentación en sus asignaciones más allá de una nota, el hecho de que un colaborador de Conéctate, desconocido para ellos, les hiciese observaciones acerca de sus mapa conceptuales, pudo haber sido muy significativo para ellos (recordemos que sus principales reacciones a las anotaciones fueron sentirse contentos, sorprendidos, orgullosos, y también nerviosos y confundidos. Segundo, dado el nivel tan bajo en que comenzaron, cabe la posibilidad que los alumnos del grupo experimental no estuvieran en condiciones de aprovechar las preguntas que se les planteaban – a menos que tuvieran a mano otro tipo de apoyo, por ejemplo, su docente. Esto pudiera ser lo que sucedió con el grupo del único docente categorizado como proactivo: antes de la intervención, los estudiantes de este docente habían construido mapas topológicamente más complejos pero semánticamente equivalentes a los de los otros tres maestros. Luego de las tres intervenciones, los mapas de estos alumnos (indistintamente de la condición experimental) superaban a los de sus compañeros en lo semántico también. Pareciera que más que los estudiantes, el directamente beneficiado por la retroalimentación fuera el docente proactivo, quien pudo aprovechar las preguntas y comentarios para guiar a sus alumnos a mejorar sus mapas mucho más que sus colegas no proactivos.

Cabe señalar que un número importante de mapas se mantuvieron sin cambios de una revisión a otra o se hicieron únicamente cambios de formato. Según el cuestionario, sólo un 41% indicó haber cambiado sus mapas. No sabemos a ciencia cierta a qué se debió esto[6], pero pareciera estar ligado al hecho de que algunos estudiantes no recibieron anotaciones, como sugiere la asociación altamente significativa entre estas dos variables. Esto constituiría evidencia adicional de que el incentivo principal para los estudiantes fue el haber recibido retroalimentación, sin importar de qué tipo. Esto tiene sentido para chicos que no están acostumbrados a recibir sugerencias para mejorar su trabajo; uno esperaría que en la medida que se de retroalimentación con mayor frecuencia, empezaría a verse que el contenido de las anotaciones (no su mera presencia) comienza a cobrar valor. Faltaría observar el efecto de la intervención en estudiantes con mapas de mayor calidad.

En un esfuerzo por trabajar con formas alternativas de evaluación, que además tuvieran la cualidad de serles atractivas y poco intimidantes a los alumnos, llegamos a la idea del collage. En la implementación de esta evaluación resultó sumamente importante la actitud de la persona encargada de aplicarla, redundando en diferencias significativas entre los grupos que recibieron un alto nivel de estímulo versus aquellos donde el estímulo fue bajo. Entre los grupos que recibieron estímulo alto estaba el del docente proactivo, pero también estaba el docente más rígido y de actitud más negativa hacia el estudio. En este sentido la evaluación resultó poco confiable. De volverse a utilizar, habría que tomar las precauciones necesarias para garantizar la uniformidad de las condiciones de aplicación del collage.

5 Conclusiones

El presente estudio exploró el impacto de retroalimentación oportuna y relevante hecha a mapas conceptuales de estudiantes de una escuela participante en el Proyecto Conéctate. Específicamente se propuso medir el potencial benéfico de formular preguntas pedagógicas para ayudar a los estudiantes – a distancia – a re-trabajar y mejorar sus mapas conceptuales. Los resultados no revelan diferencias según el tipo de retroalimentación dada; en cambio, aportan evidencia del efecto positivo en la moral de nuestros estudiantes de recibir comentarios sobre su trabajo, en la motivación que esto ejerce sobre ellos para re-trabajar sus mapas. También sugieren que pueden servirle a un docente proactivo para guiar a sus alumnos a la hora de re-trabajar sus mapas.

Pero nuestros resultados muestran algo más: el poder de publicar, de dar a conocer el trabajo propio. Por el simple hecho de que los mapas de estos niños eran públicos, personas "desconocidas" pudieron ver sus publicaciones y escribirles acerca de ellas. He ahí el valor de la gran red que Conéctate ha logrado articular. Uno de los retos que tiene el Proyecto es hacer conscientes a sus miembros que realmente están visibles en la red.

6 Agradecimientos

Agradecemos a Estela Guerrero sus valiosos aportes en la fase de definición del proyecto. Gracias también a los docentes y los estudiantes que participaron en este estudio.

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[6]Se hace necesario, en futuros estudios, controlar más de cerca el trabajo de estudiantes y docentes para garantizar que las actividades se apeguen estrictamente al protocolo experimental.

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Concept Maps: Making Learning Meaningful
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ITINERARIES: CAPTURING INSTRUCTORS' EXPERIENCE USING CONCEPT MAPS AS LEARNING OBJECT ORGANIZERS

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Abstract. An Itinerary is a concept map that serves as a guide for students on how to study or learn a particular topic. By its concept map structure, the Itinerary provides alternatives for the learner to choose how to proceed through the activities provided. An Itinerary doesn't describe the topic, it recommends how the topic can be studied, and is therefore different from a traditional descriptive concept map. Itineraries provide a level of abstraction that is more manageable by Instructors when organizing online courses than Learning Object and their repositories, and provide inherently the experience of the Instructors that create them, facilitating reusability. Itineraries were used as the mean to organize and present content for Cmappers.Learn, a site open for anybody interested in learning about concept mapping and its uses.

1 Introduction

Distance, eLearning, and online learning have come to be accepted as means by which students can obtain quality education. Until recently registering for an online course was a last resort, used only when the lecture-based course was not an option, or as a way to take elective courses that are not part of the core curriculum. This has changed as online courses have evolved, new technologies are available to support the process, and students are much more comfortable with these new technologies. Mixed mode courses, in which some activities are carried out online, are also popular. At the Techonomy Conference held in early August 2010 in Lake Tahoe, Bill Gates noted that "Five years from now on the web for free you'll be able to find the best lectures in the world. It will be better than any single university" (Siegler, 2010).

Online courses are usually administered through a LMS (Learning Management System), software for which there are versions available both commercially and as open source, that takes care of the management of the course (e.g. lists of students, grades, etc.) and provides tools such as email, discussions or forums, chats, blogs, testing, and posting of online material. However, most LMS don't provide much functionality beyond mimicking the brick-and-mortar classroom. In fact their whole structure is based on traditional classroom courses and thus the syllabus is assumed to be sequential, an online equivalent of that of traditional classroom courses. For the professor or instructor, preparing an online course is much more time consuming than a traditional classroom course since it usually requires preparing a lot more material, finding appropriate resources, and organizing them through the LMS.

One of the advantages expected from an extensive proliferation of online courses was the reusability of content from other instructors. An instructor preparing a course would take advantage of online content that had been used by others teaching the same topic, simplifying the course preparation task. Taking some pieces from one place, other pieces from another instructor somewhere else, etc., instructors would be able to piece together the content of a course tailored to their needs, reducing the effort required if new content had to be prepared. The idea of an online, digital resource that can be used and re-used to support learning brought about the term Learning Object.

2 Learning Objects and Learning Object Repositories

The Institute of Electrical and Electronics Engineers (IEEE), one of the leading organizations working on the standardization of Learning Objects (LO), defines a LO as "any entity digital or non-digital, that may be used for learning, education or training" (Learning Technology Standards Committee, 2002). Most authors consider the reusability of the LO as being a key characteristic. Daniel Rehak & Robin Mason (2003) define it as "a digitized entity which can

be used, reused or referenced during technology supported learning."

A second key characteristic of a LO is its Metadata, descriptive tags that identify the LO, characterize it and makes it "searchable". A LO's metadata may include general course descriptive data, language, instructional content (type of resource, such as text, Web page, video, image, etc.), prerequisites, and educational level, among others. Learning Object repositories would allow users to find relevant LOs for a course or topic by means of search engines looking through this metadata.

Unfortunately much of the effort placed on LOs has gone into defining a standard for the metadata, e.g. SCORM (ADL, 2010; Bohl, Scheuhase, Sengler, & Winand, 2002), and less effort on their usability and on what is a good LO. As a result, LO repositories are full of images, videos, PowerPoint presentations, etc, that are meant to be reusable but seldom are. They comply with all the characteristics of a LO, and have the full metadata description, but are of little use to an instructor looking for material to put together an online course.

Instructors preparing a new online course have three options: (a) search for a complete online course that has already been put together by another instructor on the particular subject and that is available for use, (b) develop all the online content, or (c) start searching for LOs as a means to putting together their own content. Using some other instructor's complete course has advantages and disadvantages, which we won't discuss here and should be obvious to the reader. Searching for LOs conveys two deficiencies of LOs: (a) their level of abstraction is too low, and (b) the experience gained from other instructors when using the LOs in their courses is lost.

To understand the low level of abstraction lets consider an example: an Introduction to Biology course. Practically all versions of this course include a chapter, module, or unit on cell biology. A search for LOs for cell biology within LO repositories (or on the Web) results in animations, interactive activities, videos of instructors lecturing on cell biology at other universities, texts, PowerPoint presentations, etc. As an example, a search at the Wisc-Online Web-based repository of LOs from the Wisconsin Technical College System (www.wisc-online) for "cell biology" resulted in three LOs within the Biology category: (1) Cell Division ("In this animated activity, learners examine the two major phases of cell division: mitosis and cytokinesis"), (2) The Plant Kingdom: An Introduction ("Learners read about the mutations that occurred in plants for the successful transition from an aquatic to a terrestrial existence. The classification of plants is based on these adaptive structures"), and (3) Leaves ("Learners read a general description of leaves and examine drawings and microscopic views. A matching exercise completes the learning object"). The North Carolina Learning Object Repository (www.nclor.org) also retrieved three LOs: (1) Plants and Animals, Partners in Pollination (PDF), (2) How Size Shapes Animals, and What the Limits Are (PDF document), and (3) American College of Cardiology and American Heart Association 2005 Guideline Update (Web page). Florida's The Orange grove repository (http://florida.theorangegrove.org) provided as results (1) an Animal Cell Puzzle, an interactive puzzle with versions for Biology Majors and Non-Biology Majors, (2) a Virtual Stem Cell Laboratory: Children's Hospital Boston Interactive Feature, which is an interactive laboratory at Children's Hospital Boston's website, (3) Immune Attack: An Educational Video Game, (4) a Biology textbook in PDF, and other less relevant LOs. The problem is: how does an instructor put together a course from such dissimilar material, without having to spend hours going through each of the LOs in detail?

The second deficiency is the lack of information on how these learning objects have been used or combined by Instructors in their courses. Was the Cell Division animated activity a good introduction material, or did it work better for the Instructor when used as remedial content? Where can an instructor find information on how LOs were put together by other instructors in a cohesive way to cover the Cell Biology unit? The LO repositories do not provide this information as LOs are too "atomic" in nature. The next level up of description is the complete course. We propose that an intermediate level is necessary.

3 Concept Maps as Course Organizers

Ausubel (1963) introduced the principle of an advance organizer as a more general, abstract segment of instruction that is presented prior to more specific, more detailed instruction to serve as a kind of "cognitive bridge" between what the learner already knows and the new knowledge to be learned. Concept maps can serve as advance organizers, especially when they have at the top more general, more inclusive concepts that are likely to be familiar to the learners,

followed by increasingly less general, more specific concepts and propositions lower in the concept map.

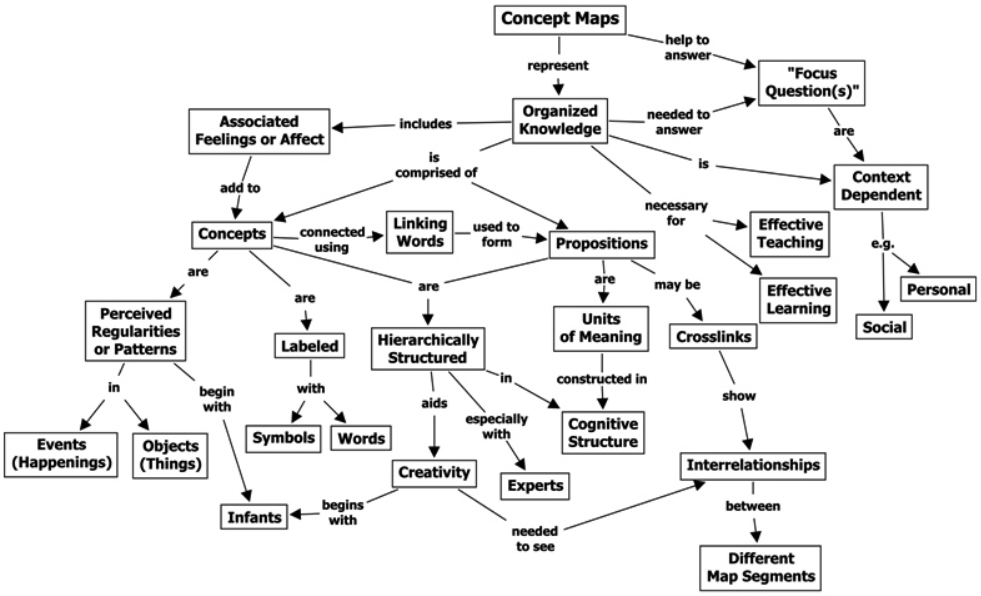


Figure 1. Concept map about concept maps (from Novak & Cañas, 2008).

Many authors have proposed and used concept maps as a means to organize course content (Basso & Margarita, 2004; Kumar & Saigal, 2005). We proposed LEO (Learning Environment Organizer) (Coffey & Cañas, 2003) as an example of how to extend concept maps to include prerequisite-type information between concepts, and links to LMS-type functionality to manage assignments and other such administrative functionalities. However, we've found that using a traditional concept map as a course organizer has a basic problem: the concept map describes the topic in a clear form, but does not explain what the student needs to do to learn and understand the topic. Observe the concept map in Figure 1, by Novak. It clearly explains what a concept map is. Now consider the learner that wants to learn what a concept map is. Even if we added links to resources, the Cmap in Figure 1 does not provide any guidance on how to proceed to *study* concept mapping.

4 Itinerary: A Concept Map-based LO Organizer

An *Itinerary* is a concept map that guides the learner through a set of Learning Objects on the study of a topic. It is based on an instructor's experience teaching the topic, is easily adaptable and reusable, and provides a good building block for constructing courses. We expand on each of these characteristics.

a) Itineraries are not descriptive concept maps

Consider the Itinerary in Figure 2 and compare it with Figure 1. The concept map in Figure 2 is not "about concept maps". It doesn't attempt to describe what a concept map is, it attempts to guide or recommend the learner on how to go about learning about concept mapping and how to learn to build concept maps. Consider the concepts from Figure 2 "Understanding What is a Concept" and "Understanding what is a Focus Question". These concepts are not objects, they are events. Novak defines a concept as a perceived regularity in events or objects, or records of events or objects, designated by a label, as shown in Figure 1 (Novak & Gowin, 1984). Each of these could be considered a competency to be inline with the competency-based learning (Voorhees, 2001). The same can be said for most, if not all of the concepts in an Itinerary. Riesco et al (2008) have proposed using a concept map of competencies for curriculum design.

b) Itineraries provide flexible, alternative learning paths

An Itinerary recommends or "advises" different paths to learning a topic. In Figure 2, the learner can decide to start the Itinerary by "Understanding What is a Concept", go directly into "Building Simple Concept Maps", or start by downloading and learning to use CmapTools. "Understanding What is a Concept" facilitates "Understanding What are Linking Words" and both are necessary for "Understanding What is a Proposition" – the learners are guided through the different competencies they need to achieve. Notice that the Itinerary recommends that "Understanding What is a Concept Map" aids in "Building Simple Concept Maps", but also that "Building Simple Concept Maps" aids in "Understanding What is a Concept Map". That is, these two competencies go hand-in-hand, and there is no clear sequential way to learn them: the more you practice concept mapping the better you understand what a concept map is, and the more you read about concept mapping the better maps you can build. Finally, all these competencies are the basis to "Learning to Build Good Concept Maps", which is another Itinerary (in the Figure, Itineraries are recognized by their larger font. In the colored Cmap they have a yellow outline). Thus the learner has choices on which way to proceed through the Itinerary.

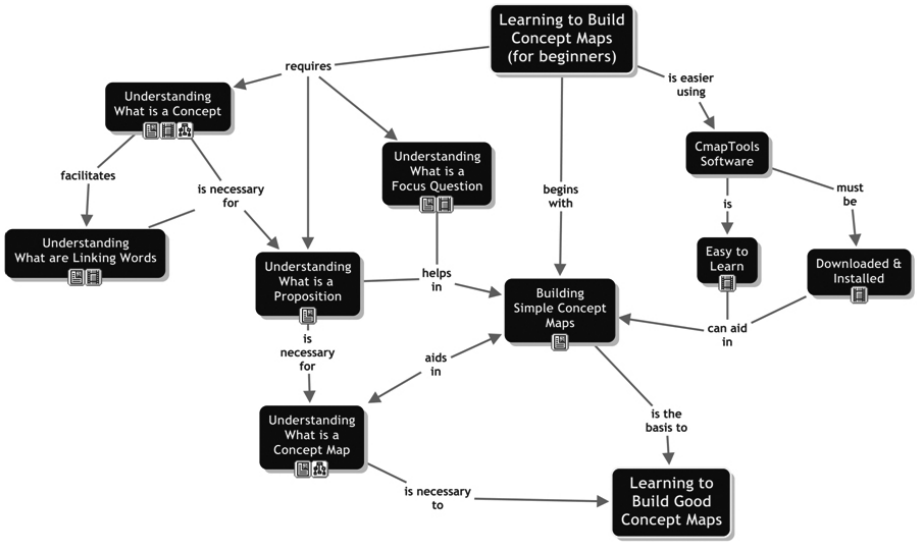


Figure 2. Itinerary on learning to build concept maps.

c) Itineraries are built by instructors based on their experience

The Itinerary in Figure 1 is based on this author's experience after dozens of concept mapping workshops: some people like to get their "hands dirty" and start building concept maps immediately while others prefer to understand the theory behind Cmaps before they sit down to build their own. For this reason the root concept provides the implicit options to the learner: it states that Learning to Build Concept Maps requires an understanding of Concept, Proposition and Focus Question, but does not force the learner into going through these topics before starting to build concept maps. At the same time it mentions that it is easier to build Cmaps if you use software such as CmapTools, but it doesn't require the use of the software.

d) Itineraries organize LOs

The icons underneath the concepts in Figure 2 indicate that there are resources relevant to the particular concept linked to it. For example, the concept "Understanding What is a Concept" has three icons: the one on the left indicates a link to a resource whose content is "text+images", in this case a link to a document that explains what a "concept" is. The icon on the right links a concept map about "concepts", and the icon in the middle links a video interview where Novak talks about "concepts". These are all LOs. It is up to the learners to decide in what order they view these LOs

– probably depending on particular learning styles. All icons underneath the other concepts in the itinerary are links to a variety of LOs. The Itinerary is thus a guide for the learner on how to study the topic (Learning to Build Concept Maps) through links to a set of LOs.

e) Itineraries are reusable

The original version of the Itinerary in Figure 1 constructed by Cañas included concepts such "Understanding the Theoretical Foundation" which linked to documents on the theory that sustains concept mapping. Comments from several instructors whose students are not studying to be teachers indicated that when they worked with concept maps they were not interested in covering the theoretical foundations, so the author removed those concepts so the Itinerary would have as broad use as possible. However, when Norma Miller (2010) created a new Itinerary, based on that in Figure 2, she decided to introduce the theoretical foundation as an important component, as is shown in Figure 3. The Itinerary in Figure 3 "reuses" the Itinerary in Figure 2, but has some important modifications. First, it adds the new concepts mentioned above. Second, although not apparent in the Figure, she used new LOs to explain Concept, Linking Phrase, Proposition, Concept Map, and Building Simple Concept Maps that go less in-depth than those linked in the Itinerary in Figure 2. She dropped the concept maps linked to a couple of concepts, but reused the rest of the LOs. The LOs linked to the concepts on "Ausubel's Theory of Learning" and "Novak's Concept Maps" were "reused", Cañas and Novak had developed them for another itinerary on "Using Concept Maps in the Classroom" (not shown). Its important to make note of the difference the effort needed on the part of an Instructor between searching for LOs in a repository to build a unit on learning to build concept maps, and starting from an existing Itinerary that can be adapted and complemented to suit the Instructor needs[1].

f) Itineraries as building blocks for course

The Itineraries in Figure 2 and 3 are not complete "courses". However, Learning to Build Concept Maps is a unit, module or chapter in many courses. With a few Itineraries like those in Figures 2 & 3 it would be quite easy for Instructors to pick the one that is more appropriate for their needs, and adapt them if necessary. If this could be done for each of the units of a course, setting up an online course would be much easier that what is available today through Object Repositories.

g) Itinerary of Itineraries

As was mentioned above, LMS enforce linear, sequential courses, mimicking the traditional classroom organization. Beyond serving as the building block for courses, the Itinerary can well be used as the course organizer. That is, the course syllabus becomes an Itinerary that links to Itineraries for each of the units or modules in the course. This way, flexible, nonlinear courses can be created that break the tradition of linearity and little flexibility that continues to exist despite the options for flexibility that technology offers.

5 Cmappers.Learn

Cmappers.Learn is the section of the Cmappers website (www.cmappers.net) open for everybody to learn about concept maps and concept mapping. The site consists of a collection of LOs, organized through a set of Itineraries. Figure 4 shows the front Web page for the site, with the list of Itineraries on the left and the list of LOs on the right. The first itinerary in the list corresponds to that in Figure 2. The second Itinerary listed shows how to use the site itself. The site is available in English, Spanish, Portuguese and Italian. If an Itinerary is available in the language the user chooses to display the site, it is displayed in that language. Figure 5 shows the Spanish version of the Itinerary from Figure 2, together with an additional feature of Cmappers.Learn: if users "obtains" an Itinerary, it is added to their Learning Center. When navigating through an Itinerary from the Learning Center, an option will display the thumbnails of the linked LOs right above the Itinerary, and users can mark those LOs that they have completed.

[1]The authors have accidentally found while using the search tool in Cmappers.net, an Itinerary stored in a CmapServer in Colombia that reuses the Itinerary in Figure 3 with some of the links to LOs changed.

Cmappers.Learn is available free to anybody interested in learning about concept mapping and its uses. Registration is done through Windows Live, and there are about 2,500 users currently registered. The site does not include any courses, provide any evaluation or certify the students. Learners are free to navigate through the Itineraries at their own leisure. Instructors interested in having their students learn about concept mapping can point them to the site and its existing Itineraries, or can reuse and adapt one of the exiting Itineraries. We invite the Cmappers community to contribute LOs and Itineraries on different uses of concept mapping to the site (Cañas & Novak, 2008).

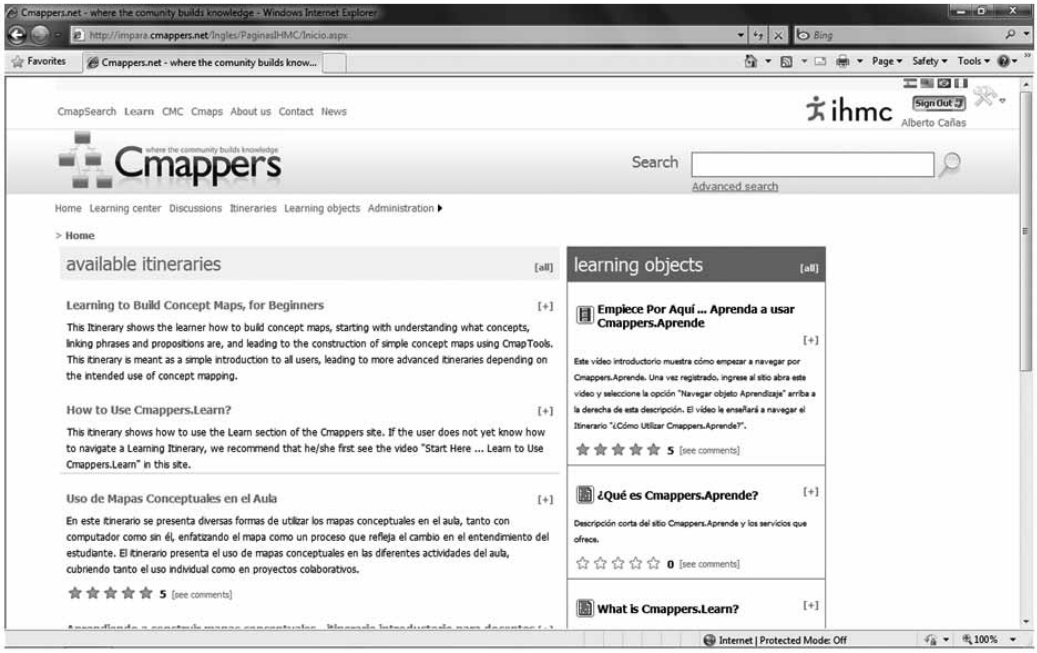


Figure 4. The Cmappers.Learn site consists of a set of Itineraries that organize a larger set of Learning Objects on concept maps and concept mapping. It is part of the Cmappers.net site (www.cmappers.net).

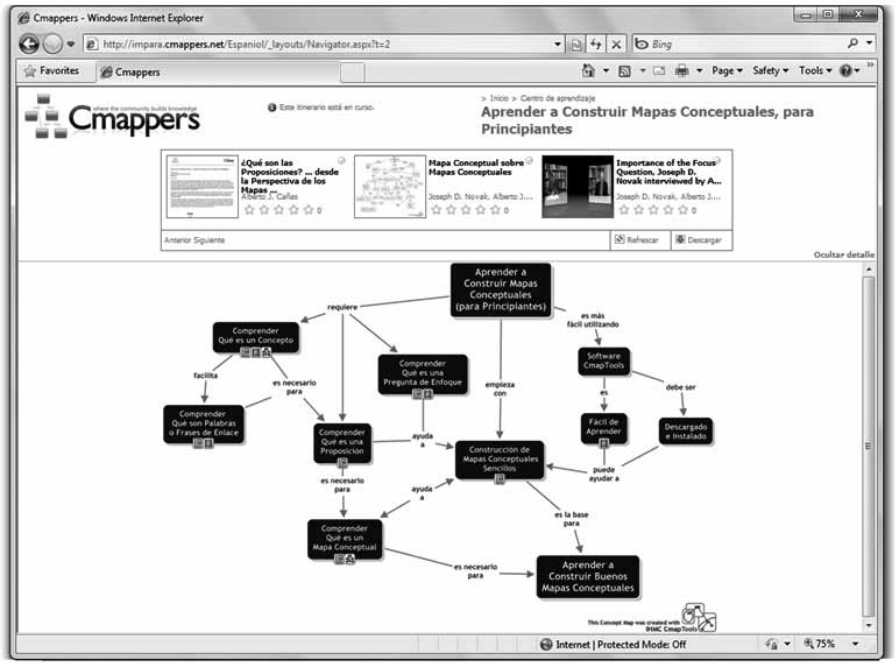


Figure 5. The Itinerary from Figure 2 shown in its Spanish version at the Cmappers.Learn site together with the option of listing the thumbnails of the LOs above the Itinerary.

6 Conclusions

We propose the use of the Itinerary, a concept map that guides the learner through the different activities and competencies needed to learn a topic, as a means of organizing LOs based on the experience of Instructors. The Itinerary provides a level of abstraction that is more manageable by Instructors creating online courses than LOs, and provides better reusability of LOs and the Itineraries themselves. Itineraries are used as the means to organize LOs at the Cmappers.Learn site, enabling thousands of users to learn about concept mapping and its applications.

7 Acknowledgements

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LA VEE Y LOS MMCC EN LA RESOLUCIÓN DE PROBLEMAS COMPUTACIONALES EN INGENIERÍA EN COMPUTACIÓN DEL IPN, EN MÉXICO.

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Resumen. El presente trabajo describe los resultados obtenidos durante la experiencia didáctica en el aula de clases al implementar la Vee de Gowin y los MMCC herramientas derivadas de la teoría del aprendizaje significativo de Ausubel, Novak y Gowin, en la resolución de problemas en asignaturas relacionadas con el análisis y diseño de los algoritmos computacionales (REPADAC), utilizada como apoyo a los estudiantes en su aprendizaje. La resolución de problemas computacionales (RPC) es un procedimiento intelectual complejo, en el cual no se deben pasar por alto las distintas acciones que realiza nuestra inteligencia para resolverlo, ésta solución debe estar al alcance del nivel de desarrollo cognitivo y de las capacidades del grupo de estudiantes, se deben proponer problemas simples para desarrollar capacidades complejas, éstos problemas deben reflejar la vida cotidiana. Para la RPC por parte del alumno, influye en gran medida el grado de complejidad del problema y el interés que despierte resolverlo, su capacidad creativa, su habilidad. La efectividad del algoritmo no se valida simulando la solución, se tiene que hacer uso de formulismos matemáticos que de manera formal lo demuestren ya sea por inducción matemática o como lo sugiera Knuth (1977), por medio de método finito de cálculo. La metodología seguida se inició con el análisis de las observaciones en el aula de clase, a partir de éstas se planteo la pregunta de investigación y la construcción de las herramientas de evaluación a utilizar para validar la hipótesis planteada, a través del registro y análisis de datos se obtuvieron los resultados que se describen en la sección de análisis y discusión de resultados.

1 Introducción

El origen del aprendizaje significativo surgió del interés por conocer y explicar las condiciones y propiedades del aprendizaje, cambios estables cognitivos, significación individual y social para resolver problemas como: naturaleza de la adquisición y retención del conocimiento organizado, desarrollo de capacidades de aprendizaje y resolución de problemas (Ausubel, 1976).

La teoría de aprendizaje de Ausubel (1978), parece ser consistente con la idea central de la epistemología que Novak toma en cuenta en sus investigaciones relevantes para su teoría de aprendizaje, ya que Ausubel presenta una teoría de aprendizaje cognitivo dirigido al aprendizaje humano y a la realidad que se vive en las escuelas, en la posición del aula de clases. Novak y Gowin (1984) coinciden con Ausubel en que el aprendizaje significativo es una incorporación de nuevos conceptos de forma no arbitraria y sustantiva en la estructura cognitiva de los estudiantes.

Para Moreira (2000: p. 10), "es un proceso a través del cual una misma información se relaciona, de manera no arbitraria y sustantiva (no literal), con un aspecto relevante de la estructura cognitiva del individuo". Dos herramientas han sido desarrolladas por Novak y Gowin a partir de ésta teoría; la Vee de Gowin y los mapas conceptuales. Los primeros trabajos sobre la Vee de Gowin se iniciaron en la Universidad de Cornell, USA (Cardemone, 1975; Bogden, 1977; Moreira, 1977), con estudiantes universitarios. El diagrama de la Vee de Gowin se basa en un estudio epistemológico de un acontecimiento, y constituye un método simple y flexible para ayudar a estudiantes y docentes a captar la estructura del conocimiento y del modo como éste se produce (Gowin, Alvarez, Marino, 2005). Se trata de un diagrama en forma de V, en el que se representa de manera visual la estructura del conocimiento (González, 2008).

Gowin (1981) la propone como una herramienta para ser empleada al analizar críticamente un trabajo de investigación, entender un experimento en el laboratorio, en una enseñanza dirigida a promover un aprendizaje significativo, así como "extraer o desempaquetar" el conocimiento de tal forma que pueda ser utilizado en la resolución de problemas (Moreira; 1990a).

El diagrama Vee, desafía a los investigadores a ser más precisos y explícitos sobre el rol que le otorgan a sus visiones el mundo durante la ejecución de la investigación; les obliga a pensar sobre las filosofías, teorías, principios/

leyes y conceptos que guían su trabajo. Los componentes de este lado, por lo tanto demandan integración con los del lado derecho (Moreira; 1990b).

El objetivo del presente trabajo fue implementar un modelo de enseñanza basado en la teoría del aprendizaje significativo de Ausubel y Novak, que apoyó al estudiante de la carrera de ingeniería en computación en la REPADAC en el tema del paradigma orientado a objetos. En la Escuela Superior de Ingeniería Mecánica y Eléctrica de la Unidad Culhuacán (ESIME-Cu) en ingeniería en computación (IC), se han realizado estudios previos en los cuales se ha dado a conocer estrategias metacognitivas como la Vee de Gowin para promover el aprendizaje significativo en el DAAC (Guardian, 2003,2004, 2005), por la autora, la experiencia en esas implementaciones, se puede afirmar que ésta le ayudó a los estudiantes a autoregular su conocimiento, permitiéndole el planificar, controlar y evaluar el proceso de desarrollo de la construcción de los algoritmos, para detectar posibles fallas en el proceso de aprendizaje (Guardian, 2009).

El diseño de los algoritmos computacionales representa un problema para que los estudiantes aprendan a programar, y ésta tarea es la parte medular de su carrera. El presente trabajo se realizó para a ayudar al alumno a evolucionar desde su estructura cognitiva hacia la organización lógica de la manera en que ésta aprendiendo, y por tener interés como docente de guiar al alumno, hacia un aprendizaje significativo en la edificación de algoritmos computacionales óptimos como solución de los problemas planteados; ésta ha sido la justificación más relevante.

2 Implementación en la enseñanza de la POO

El uso de la Vee y los MMCC en la enseñanza de la programación se consideró como una estrategia y herramienta de apoyo en el aprendizaje significativo de los alumnos, por las razones antes descritas, su implementación al inicio no fue fácil, es difícil que los estudiantes acepten cambiar de métodos de estudio o la manera de aprender, están acostumbrados a una enseñanza centrada en el profesor, aprender a usar una herramienta metacognitiva no fue al inicio aceptada por el tiempo que creen le tienen que dedicar a entenderla para poder implementar, se buscó la forma de hacerla flexible para su uso en la construcción de los algoritmos, y en la evaluación se presentó como un método rápido y sencillo, en el cual la valoración de los diagramas construidos por los alumnos se realizó a partir de puntaje a los elementos incluidos.

3 Metodología

3.1 Etapa 0 o pre-inicial

Esta se realizó en cuatro etapas como se muestra en el mapa conceptual de la figura 1: Antes de iniciar el curso se aplicó a los estudiantes una entrevista con la finalidad de conocer su entorno social, económico y académico, así como los métodos de estudio utilizados por los estudiantes. Se aplicaron dos test, uno de conducta y otro de actitud para conocer éstos aspectos del alumno. Se registraron y analizaron los datos obtenidos de los instrumentos de evaluación mencionados, ésta información fue de gran valor para planear el curso, diseñar el material didáctico a utilizar, analizar y rediseñar y reorganizar los contenidos de manera lógica y coherente para hacerla más clara al alumno, así como la elaboración de los manuales del laboratorio, prácticas y apuntes. Para Gowin (1970) los materiales educativos son considerados acontecimientos previos que los seres humanos pueden usar para hacer que nuevos acontecimientos sucedan, y que para ser didácticos deben tener significados extraíbles y re construibles tanto por el docente como por el estudiante, para que puedan compartir los significados.

3.2 Etapa 1. Inicio-curso

En la primera semana de clases, se aplicó el examen diagnóstico, con la finalidad de conocer los conocimientos previos del alumno, así como detectar los errores conceptuales de cada estudiante, este examen estuvo constituido por una lista de preguntas cerradas, problemas propuestos y una lista de conceptos con los cuales el alumno construyo un mapa conceptual jerarquizando, ligando éstos con palabras de enlace, agregando los conceptos que el alumno consideró importante agregar.
Basándonos en ésta información se replanteo el objetivo general del curso, los objetivos de cada unidad de aprendizaje, se reestructuro el material didáctico y se reorganizaron los contenidos del curso, los métodos de evaluación, así como estrategias a implementar para cada unidad temática, prácticas de laboratorio estrechamente ligadas a la teoría.

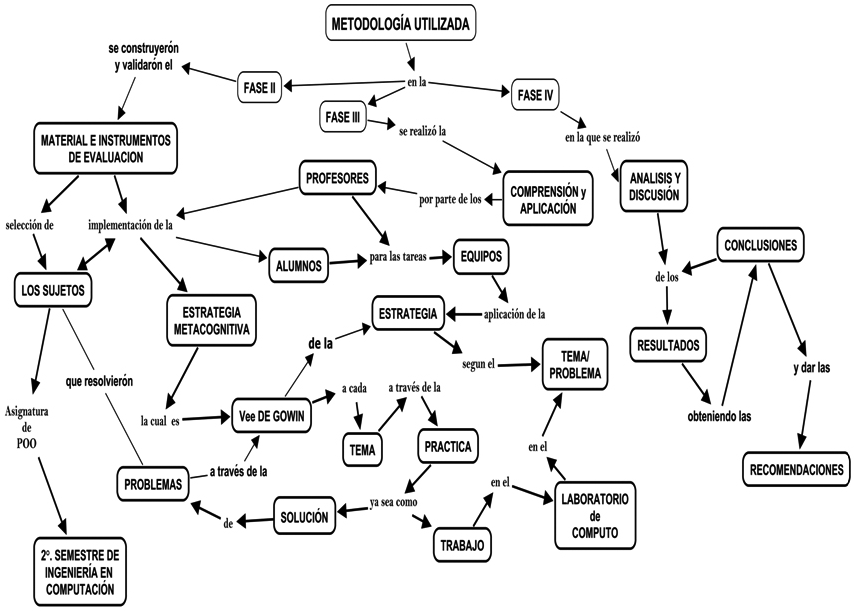


Figura 1. Metodología de la enseñanza implementando estrategias metacognitivas

3.3 Etapa 2. Durante _ curso

Se impartió los temas utilizando como estrategia la Vee de Gowin y los MMCC, construyendo los mapas para cada tema en colaboración con los estudiantes, a los cuales se les agrupo en equipos de máximo 4 estudiantes, para que en trabajo colaborativo, construyeran y discutieran sobre cada mapa conceptual construido.

La clase de resolución de problemas a través de algoritmos computacionales fue apoyada con la Vee de Gowin como estrategia didáctica, se utilizó la misma dinámica que con los MMCC, durante el curso en cada unidad del contenido del curso y una para cada práctica del laboratorio. Para la evaluación de las V de Gowin construidas por los estudiantes se utilizó un criterio de asignar puntuación a cada elemento de la V, tanto en las construidas para las prácticas del laboratorio, como en la resolución de los problemas propuestos en la clase teórica, también aquí se elaboraron las V de Gowin por grupos pequeños de no más de tres estudiantes, los cuales participaron de acuerdo a lo indicado en el manual que se les proporcionó al inicio del curso, sobre lo relacionado a la V de Gowin, sus preguntas y dudas fueron resueltas tanto en asesoría presencial como por correo electrónico, para guiar correctamente el proceso, en este proceso la tutoría al alumno fue de gran importancia.

El análisis de las V de Gowin elaboradas por los estudiantes permitieron evaluar la construcción del conocimiento de los alumnos y la forma como interaccionan la teoría y la práctica. El uso de la V invierte las afirmaciones piagetianas sobre el razonamiento, ya que supone que los estudiantes de cualquier edad puede parecer que operan en el nivel concreto o formal, dependiendo de lo adecuado que sean sus marcos conceptuales relevantes. Para éste análisis construyeron dos hojas de observación y evaluación.

Con respecto a los mapas conceptuales construidos por los estudiantes, estos se evaluaron por el número de conceptos empleados, la jerarquización de éstos, los enlaces cruzados a través de puntuaciones dadas a cada elemento de los mapas conceptuales, para comparar la evolución en el aprendizaje de conceptos de los estudiantes.

A través de una lista de conceptos con los cuales los alumnos tuvieron que construir un mapa conceptual así como agregar conceptos que ellos considerarán necesarios, jerarquizarlos y relacionarlos, para detectar errores conceptuales y el conocimiento previo del estudiante y se valoran las proposiciones que identificó, así mismo contestaron la prueba de conocimientos que consistió tanto de preguntas cerradas como de abiertas para conocer las habilidades y destrezas del alumno en la resolución de problemas a través del DAAC, para lo cual se les dio el tiempo suficiente para que éstos contestaran de acuerdo a los conocimientos previos con sumo cuidado y tiempo.

3.4 Etapa 3 Final _ curso

Al finalizar el curso se aplico la pos-evaluación, y el cuestionario final de opinión, éste último para conocer las facilidades o dificultades de los alumnos al utilizar la Vee de Gowin y los MMCC, también nos permitió conocer la utilidad o no de éstas técnicas como apoyo en la solución de problemas.

Materiales: Con el fin de recoger toda la información de manera fiel, se utilizó grabadora y guión de entrevista así como cuaderno de notas, y el lugar en donde se llevaron a cabo fue en el auditorio del departamento por ser un lugar amplio y cómodo.

El registro de estos datos sirvieron de base para la planeación didáctica del curso, ya que se reestructuró los temas del curso de manera más transparente para el alumno y apoyando con las estrategias como la V de Gowin y los mapas conceptuales, esta información registrada también fue la base para la elaboración del material didáctico y de apoyo como fueron:

a)Apuntes en los cuales cada tema se describieron los objetivos por tema y subtema, métodos y estrategias de apoyo, se dieron ejemplos y resolvieron ejemplos utilizando la Vee metacognitiva de Gowin, la parte teórica fue apoyada con los mapas conceptuales.

b) Manual de laboratorio: constituido por las prácticas, cada una de ellas con la especificación de los objetivos, metas, teoría requerida y un ejemplo desarrollado con la V, forma de evaluación.

c) Manual de la V y heurística de Gowin: El cual describe paso a paso la forma de construir la V de Gowin, con ejemplos y aplicación de cada uno de los elementos ésta técnica.

d) Manual del cmaptools, para que el alumno utilizará el software para construir sus mapas conceptuales, atendiendo a la necesidad de los alumnos de utilizar los sistemas de cómputo, al ser ingenieros en computación.

Para el profesor universitario la elaboración de mapas conceptuales le va a permitir conocer lo que el alumno sabe en relación con una temática determinada y en base a ese conocimiento elaborar material curricular e instruccional conceptualmente transparente, aumentando así la eficiencia y eficacia de su labor (González, Casali, et all, 2007)

4 Resultados

Para el registro de los datos obtenidos al aplicar los instrumentos de evaluación como fueron; entrevistas, mapas conceptuales, diagrama V de Gowin, instrumentos finales y las calificaciones obtenidas en las evaluaciones fueron procesados en software informático SPSS. De la información registrada se realizó un análisis cualitativo y cuantitativo.

Test Value = 0	T	Media	Desviación Estándar	95% Intervalo de confianza
EXAMEN DIAGNOSTICO	10.471	5.90	3.042	3.00
POST¨-EVALUACION	39.690	8.89	1.927	8.45

Test de conocimientos y mapas conceptuales del grupo experimental semestre 02-2009

Tabla 1. Examen diagnostico y post-evaluación: Std desviación

Para el registro de datos y análisis del examen diagnóstico de conocimiento y la lista de conceptos para que el alumno elaborara un mapa conceptual se tomo en consideración de las variables que habían mostrado ser relevantes en los estudios previos, éstas fueron: i) si el alumno es repetidor del curso; ii) si el alumno ha llevado cursos previos de programación en el nivel medio superior; iii) si el alumno trabaja; iv) Los alumnos que tienen conocimientos sobre el uso de las estrategias cognitivas.

Interpretación de los resultados encontrados en el examen diagnóstico con respecto a las variables que podrían afectar los resultados finales del estudio éstas no fueron significativas. El análisis estadístico de los datos recolectados concerniente a esas variables para cada par de grupos (experimental y control) resultaron no incidir de manera importante en los resultados finales.

En la Tabla 1 se puede observar una tendencia hacia la avance en el rendimiento en el grupo experimental, en el transcurso del semestre 02-2009. De un total de cuatro grupos se produjeron progresos en el rendimiento en dos grupos los que pertenecen al experimental, mientras que los otros dos (control) no empeoró, pero tampoco avanzó significativamente

En la Tabla 1 en el primer momento se obtuvo la media la cual es favorable para el grupo experimental y en el segundo momento la desviación estándar a través del paquete SPSS y como se puede apreciar en ésta el examen diagnóstico (5.042), los datos se han dispersado más que en el examen post evaluativo (1.927), hay más dispersión de datos en el examen diagnóstico y el promedio en el grupo experimental fue mayor, se puede observar las diferencias de resultados de la post-evaluación entre grupo experimental y control (Stevenson, 2004: p: 22-33).

El porcentaje que participó en la investigación por género, fue el 72.5 % del sexol masculino, esto es muy importante ya que el análisis también se realizó desde la perspectiva de género, para entender el porqué siempre existe en al menos un 70% estudiantes varones y la población femenina ha llegado a ser incluso de 5 % en algunos semestres, lo anterior a pesar que se han hecho estudios anteriores en donde ambos sexos tienen las mismas capacidades y destrezas en ésta ingeniería, y las edades en su mayoría en el curso del semestre fue de 18 años, por ser del turno matutino, ya que en estudios anteriores en donde se incluye el turno vespertino la edad promedio es entre 19 y 20 años.

Los resultados obtenidos al aplicar el examen diagnóstico y la post-evaluación hubo un avance conceptual de los estudiantes en un promedio de grupo, también se realizó un análisis comparativo por alumno.

En el primer momento se obtuvo la media la cual es favorable para el grupo experimental y en el segundo momento la desviación estándar a través del paquete SPSS y como se puede apreciar en ésta el examen diagnóstico (4.41), los datos se han dispersado más que en el examen post evaluativo (1.927), hay más dispersión de datos en el examen diagnóstico y el promedio en el grupo experimental fue mayor, se puede observar las diferencias de resultados de la post-evaluación entre grupo experimental y control.

La Figura 2 muestra un comparativo por estudiante de los resultados del examen diagnóstico y el de la evaluación al final del curso como se puede observar en un ´porcentaje mayor los estudiantes mejoraron después de implementar la metodología propuesta.

En ésta Figura se puede ver el comparativo del examen diagnóstico y post-evaluativo por estudiante. Como se puede observar, sólo los estudiantes 5, 15, y 17 no mejoraron incluso en el examen post-evaluativo. Su calificación fue menor como en el caso del estudiante 15 y 17 que su pre evaluación, lo cual es de poca significancia en comparación con el porcentaje de alumnos que mejoraron.

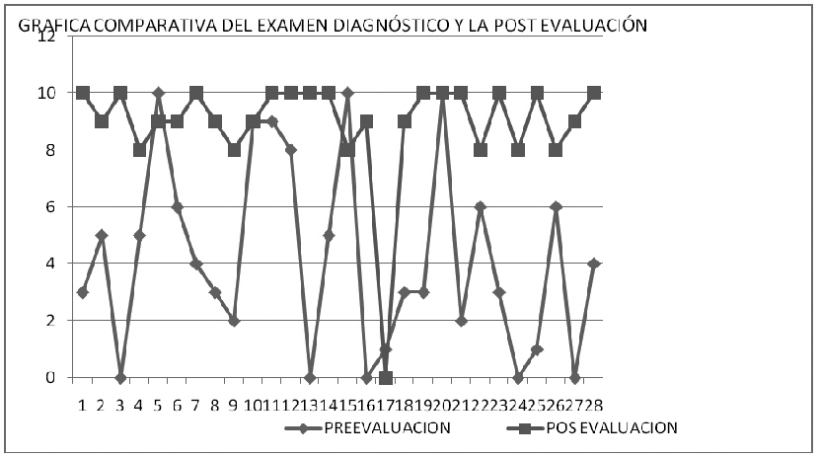


Figura 2. Comparativa por estudiante de la pre y post evaluación

5 Conclusiones

A partir de los resultados obtenidos, podemos concluir que el atender a la sugerencia de Gowin en su modelo tríadico, en donde realza el dialogo entre el profesor, alumno y material educativo, y de Novak con su teoría humana de la educación, se lograron resultados positivos tanto en las evaluaciones, como en el avance conceptual del grupo experimental en relación al grupo control.

¿Existirá una variación significativa en los indicadores de un proceso de aprendizaje más significativo, en el grupo experimental y en relación al grupo control, mediante el uso la V en el análisis y diseño de los algoritmos?
Con base en los análisis de los resultados de las entrevistas y los test de actitud y conducta así como las pruebas de
¿Existirá una variación significativa en los indicadores de un proceso de aprendizaje más significativo, en el grupo experimental y en relación al grupo control, mediante el uso la V en el análisis y diseño de los algoritmos?
Con base en los análisis de los resultados de las entrevistas y los test de actitud y conducta así como las pruebas de
conocimiento aplicado antes y al finalizar el curso, la prueba de actitud y la opinión de los alumnos sobre el material de los contenidos del curso, se puede concluir qué:

Hay evidencias de que los alumnos si lograron tener un aprendizaje significativo, esto se puede afirmar porque se cumplieron las tres condiciones necesarias para lograr un aprendizaje significativo.

En la presente investigación el grupo al cual se le enseño bajo el modelo propuesto se logró integrar la teoría y la práctica a través de la V de Gowin, esto, no solo produjo enriquecimiento de aspectos metodológicos o estrictamente teóricos, sino que nos permitió sacar conclusiones de la práctica docente diaria.
Sobre las hipótesis: H1"Hay una mejora en la calidad de indicadores de aprendizajes significativos entre los estudiantes en el cuál se implemento la V de Gowin bajo la teoría de Ausubel, Novak y Gowin en el diseño de algoritmos, en relación con el grupo control".

H0"No hay una mejora en la calidad de indicadores de aprendizajes significativos entre los estudiantes en el cuál se implemento la V de Gowin bajo la teoría de Ausubel, Novak y Gowin en el diseño de algoritmos, en relación con el grupo control". Se midió el progreso paulatino del alumno a través del análisis cualitativo de las Vee de Gowin construidas por el alumno tanto para 11 prácticas del laboratorio, como en los problemas propuestos en la clase de teoría, para lo cual se utilizó la tabla de registro de puntos para el análisis de cada uno de los elementos de la V de Gowin.

Los mapas conceptuales y las ECPM se utilizaron en el examen diagnóstico y la post-evaluación como instrumentos cualitativos para conocer la variación de la estructura cognitiva del alumno, estar al tanto a lo que el alumno sabía con respecto a los conocimientos previos que debería tener para asimilar y aprender el nuevo contenido de la asignatura de programación orientada a objetos, objetivo que fue realizado satisfactoriamente, de acuerdo a los resultados obtenidas y a través de las medias y la desviación estándar, se rechaza la hipótesis nula y se acepta la hipótesis alterna.

La validación de las la hipótesis:

En relación a las hipótesis:
1. H1" Hay una mejora que se pueda considerar significativa en relación al rendimiento académico entre los estudiantes en el cuál se implemento la V de Gowin bajo la teoría de Ausubel, Novak y Gowin en el diseño de algoritmos, en relación con el grupo control."
2. H0" No Hay una mejora que se pueda considerar significativa en relación al rendimiento académico entre los estudiantes en el cuál se implemento la V de Gowin bajo la teoría de Ausubel, Novak y Gowin en el diseño de algoritmos, en relación con el grupo control."

El análisis de las medias y la desviación estándar obtenidas de los resultados finales de los exámenes departamentales, reporte y exámenes de las prácticas de laboratorio, los mapas conceptuales construidos al inicio y al final del curso de acuerdo a los resultados obtenidos, nos aportaron evidencias significativas de que el grupo experimental mejoro su rendimiento académico y éste fue mayor al del grupo control, el cual no empeoro pero tampoco incremento su rendimiento académico significativamente, por son siguiente y dadas las certidumbres: Se rechaza la hipótesis nula y se acepta la hipótesis alterna.

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LIVEMAPPERS: A LEARNING ENVIRONMENT FOR CONCEPT MAP-BASED COLLABORATIVE PROJECTS

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Abstract. Collaborative learning is accepted as an effective means of offering students a stimulating and challenging environment where they can learn from each other, at their own pace, through research and questioning. Within a concept-map based learning environment, collaborative projects offer the opportunity for sharing among students in their meaning making and understanding while jointly building concept maps. CmapTools offers a broad range of tools to support collaborative concept mapping. However, we find few cases where meaningful collaborative projects are being carried out between schools. We believe that more technological infrastructure beyond that provided by the CmapServer is necessary to support collaborative concept mapping in schools. In this paper we present LiveMappers.net, a Web-based learning environment integrated with CmapTools that supports concept map-based collaborative projects. LiveMappers offers teachers a set of Project descriptions to choose from and the opportunity to join an Instance or execution of a Project, or teachers can design their own Project and invite colleagues to join. LiveMappers provides each Instance or execution of a project with an environment for students to collaborate supported by Web-based access to shared folders on a CmapServer preset with permissions for sharing among students, the ability to launch CmapTools from those folders to construct and share Cmaps, a common Blog and a Discussion Forum for students and teachers. LiveMappers.net scales up to support thousands of teachers and students participating in collaborative projects.

1 Introduction

Vygotsky (1978) stressed the importance of social exchange in learning, especially with learners who are at about the same Zone of Proximal Development (ZPD). That is, students who are at about the same level of cognitive development (same ZPD) on a given topic will enhance each other's learning if they engage in active exchange of ideas. It is not until recently that educational systems have begun to comprehend and put into practice the benefits of collaborative learning. While some years ago any type of "help" that students would be provide each other was seen as cheating, now teachers promote students learning from each other and working in teams.

The push for collaborative learning has come not only from the theoretical work by Vygotsky and others and the practice of teachers, but also from the workplace: organizations and corporations require knowledge workers that have experience in working with peers. Within the current fad of teaching competencies, "collaboration" is included as one of the key competencies that students must achieve as part of their education (e.g., Jerald, 2009).

Collaboration and project-based learning are a natural blend (Coffey, 2010). Together they provide a comprehensive approach where students can learn together, exchange ideas, integrate subjects and advance at their own pace. And when the project is executed within a concept map-centered learning environment (Cañas & Novak, 2005; Novak & Cañas, 2004) students get involved in meaning negotiation and discussions while they collaborate in the construction of their concept maps.

The CmapTools software (Cañas, et al., 2004) was designed to support collaboration, both synchronous and asynchronous, through tools and functionalities such as shared folders in servers, annotations, discussion threads, knowledge soups and asynchronous collaboration. Tifi & Lombardi (2006) report on the use of the software in an international collaboration community, and others have reported the use of the tools for collaboration (Correia, Infante-Malachias, & Godoy, 2008; Torres & Marriott, 2010).

Even though collaboration among students is widely accepted as an educational activity that fosters meaningful learning, and combining collaboration with Project Based Learning results in motivating activities for students, we find few cases of effective collaborative projects among schools, and even less of concept map-based collaborative projects. Even though CmapTools provides the environment and tools for collaborative construction of concept maps it does not include the complete environment necessary for collaborative projects, particularly when the projects involve more than one school. In this paper we present LiveMappers.net, a learning environment that supports collaborative concept map-based projects among schools.

2 Characteristics of Collaborative Projects

2.1 The Challenges of Collaborative Projects

Carrying out a collaborative project involving students from different schools, and particularly from different countries, is a challenge. First, coming up with a well-structured project that lends itself to collaboration is harder than it seems, particularly one where students really require of the collaboration with students in the other schools to perform their work. Monitoring students and their progress is not easy: three collaborating classrooms each with 25 students require managing the work of 75 students. When the schools are from different countries or regions, the coordination becomes more complex. There will be differences in curriculum (each teacher will want to cover the material that is included in his/her curriculum, which is most likely not the same), culture (how important is it in each culture to keep deadlines during exchanges with other students?), calendar year (Northern and Southern Hemisphere schools tend to have few overlapping weeks of classes once one removes unproductive periods such as the beginning of the semester, the end of the semester, mid-semester breaks, long holidays, etc.). As a result of these challenges, the collaborations between schools are often either:

a) Trivial in content, where the benefits derive mainly from getting to know the other students, understand their differences and commonalities, and not from engaging in some in-depth activity, such as those involving research or problem solving.

b) An exchange where no real collaboration takes place, and the process consists mainly of each classroom doing its own work and exchanging results or ideas at the end through some forum, videoconference or chat.

c) The effort never reaches a conclusion: the collaboration does involve problem solving or research, but it never reaches a conclusion; time tends to drag on, the students and teachers lose interest, stop communicating, and the project never reaches the end.

It is clear that the interaction of students with peers from other regions or countries offers learning experiences that can lead to increased tolerance and comprehension among cultures with long-term implications for society, and we are not trying to discourage it. However, so much more can be additionally achieved through in-depth collaboration that our effort goes in the direction of investigating what issues prevent it and how to overcome them.

2.2 Difficulties in Executing Collaborative Projects

As mentioned above, there are known challenges that teachers and students must overcome when organizing and participating in collaborative projects. In this section we extend our discussion of these challenges.

2.2.1 Lack of experience on the part of the teacher

Few teachers have experience participating in collaborative projects, and for many a collaborative project is also their first attempt at project-based learning. As such, teachers (and students) don't really know what to expect, what is involved in participating, and the challenges ahead. This lack of experience becomes a real issue when combined with the other challenges below.

2.2.2 Where to find a project and a teacher or school willing to collaborate

Because teachers have little experience carrying out collaborative projects involving other teachers, most don't know where to start. What projects can they participate in? Where do they find a teacher or a school willing to collaborate? How do they get the project going? In most cases, collaborative projects take place among schools under the umbrella of an existing organization. The facilitators for the organization set up the projects and invite the teachers, taking the role of coordinators. However, many teachers don't have this support organization (or their umbrella organization may be, for example, the Ministry of Education of their country/region which does not facilitate collaboration), and therefore have to look for themselves for projects in which to participate.

2.2.3 Project not well defined or organized

Delineating a collaborative project is not easy. These are aspects that are often lacking in collaborative projects:

a) Well-delineated collaborative activities that involve a collaborative effort among students, where students cannot perform their work without the collaboration of their peers from other schools.
b) Lack of a predefined schedule agreed upon by the teachers, and a commitment by all of them (and their students) to comply with the dates. If students depend on their peers to be able to complete their own work, they need to understand the importance of keeping with dates and interactions.
c) Outcomes and deliverables not well defined. The agreed-upon schedule must be linked to expected outcomes and deliverables, so its clear what will be done by whom by when. In the case of projects involving collaborative concept mapping, the outcome and scheduled would include the dates by which concept maps or knowledge models (Cañas, Hill, & Lott, 2003) would be completed.
d) Student's individual participation not clear. Often the whole class participates in the activities as a group, and individual students don't have well defined role. It is important that all students actively participate in the collaboration, whether through individual roles within the class, or by splitting them into small groups that include students from different schools.

An argument could be made that having such well-defined activities and schedule limits the creativity of teachers and students, and that teachers and students should be able to define their own projects. We agree, and the LiveMappers.net environment allows teachers to design new projects with their students, and to make these projects available to other teachers. However, our experience with teachers, particularly those that have not participated in collaborative projects before, is that a well described project allows them to (a) decide whether they want to participate in the project, and (b) understand what they are getting to, and (c) know what to expect if they participate in the project. As they become more experienced they can then move into designing their own projects.

2.2.4 Lack of a supporting software platform

There are many sites with lists of interesting projects and their descriptions. But they seldom involved a software platform for the teachers and students of the various schools to collaborate. We often find that the teachers "agree" to use combination of platforms for their project, e.g. Messenger or Skype for video-conferences, email for communication, Yahoo for group communication, different sites for Blogs and/or Wikis, and a public CmapServer for concept map-

ping. It becomes difficult to handle a large number of students with so many different sites involving different userids, passwords, and interfaces. The project becomes unmanageable. Sometimes the teacher's umbrella organization provides a collaboration environment, e.g. Moodle-based, which makes the project more manageable. Social networking environments provide the communication tools and publishing tools, but they were not designed to implement collaborative projects. Furthermore, none of these tools were designed to facilitate concept mapping-based collaboration. A learning environment is needed that allows a group of teachers with their students to have their own space to execute their collaborative project, provides supporting tools such as concept mapping, blogs, and discussions, and where both individual and group spaces can be defined for the different activities with corresponding permissions. LiveMappers.net is such an environment.

2.2.5 Scalability

All the issues described above magnify when multiplied by the thousands of teachers that use concept mapping and that potentially would participate in concept map-based collaborative projects if they had the opportunity. The problem then becomes one of scalability. How do thousands of teachers find an interesting project and other teachers with whom they can collaborate? It would be preferable if the learning environment that supports concept map-based collaborative projects scales to large numbers of teachers and projects.

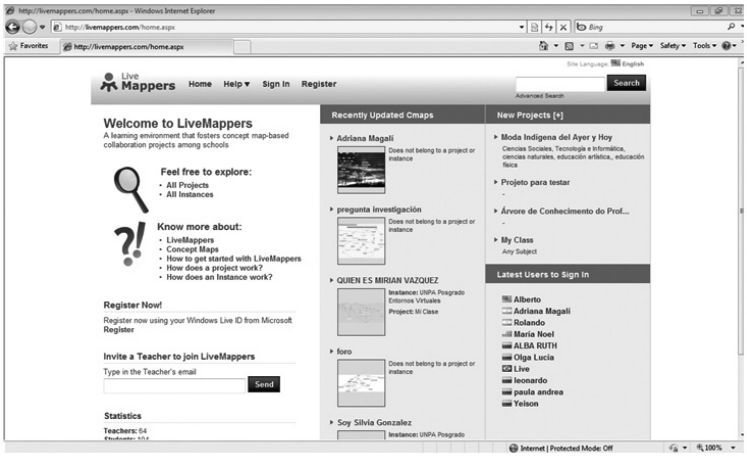


Figure 1. The main page of the LiveMappers.net website showing recently updated Cmaps, New Projects and Latest Users to Sign In.

3 LiveMappers.net

LiveMappers is a learning environment that fosters concept map-based collaborative projects among K-12 schools and attempts to address the challenges described above. In LiveMappers teachers can find a collaborative project that suits their needs, interests, and schedule. They can register for the project, and through the LiveMappers site, their students can collaborate with students from other classrooms, who can be in other countries, other regions or within the same school. Additionally, teachers with their students can propose and create their own projects and execute them within LiveMappers. The site has been designed with the objective that students use concept maps as the artifact over which they collaborate, using CmapTools as the software tool to construct and share their concept maps. Figure 1 shows the Welcome page for the Livemappers.net site.

3.1 Project and Instance

LiveMappers consists of descriptions for a set of Projects which include, for each Project, its Overview, Purpose, Des-

cription, Requirements, etc. and a suggested Schedule for activities the students need to carry out during the execution of the Project. This information allows teachers to decide which Projects suit their needs and interests, based on the grade, the subjects involved, and the time frame for the Project. Figure 2 shows an example of a Project called "Home Remedies". In "Home Remedies" students interview their grandparents and elderly relatives and friends of the family for home remedies used to treat particular diseases, illnesses and discomforts. The students act as "Knowledge Engineers", creating concept maps from the interviews. Since students are assigned to groups, where each group includes a couple of students from each participating school, the students for each group will then integrate the concept maps for each disease, leading to a group's knowledge model (a knowledge model is a collection of linked concept maps and associated resources about a particular domain). Eventually a knowledge model is created for all the home remedies from the different groups, and the Forum is used for discussions among students.

Figure 3 shows part of the proposed Schedule for Home Remedies. The Project's Schedule is a "suggested" schedule, since at the time the Project is executed it will be changed to specific dates and adapted according to the participating teachers' requirements. The Schedule for a Project consists of 4 phases: (1) Registration, (2) Preparation, (3) Execution, and (4) Finalization. The entries in the Project's Schedule only contain the duration for events and activities. To further describe the parts of the Schedule we need to first introduce the concept of the Instance of a Project.

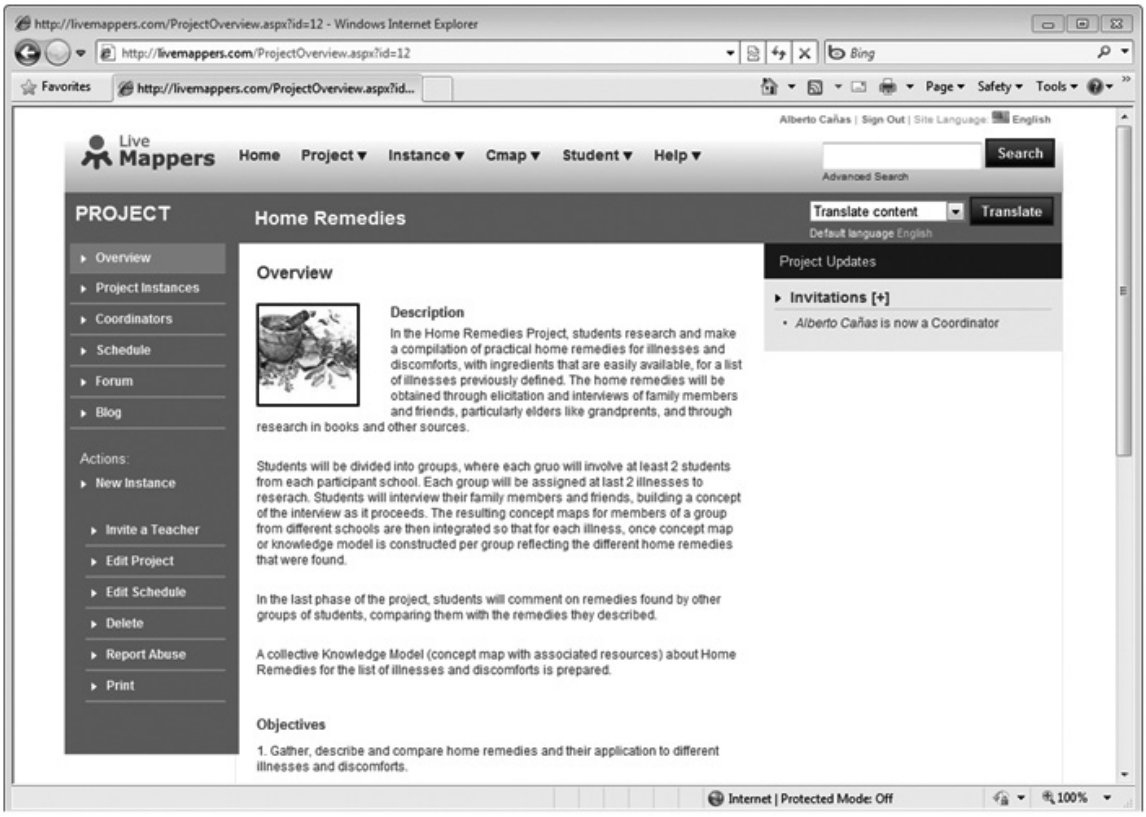


Figure 2. A Project description in LiveMappers includes Overview, Purpose, a link to a document with details, a Schedule, Blog and Forum. Each Project can have multiple executions, called Instances. The Schedule is shown in Figure 3.

The execution of each Project within LiveMappers is called an Instance of the Project. For any Project, there can be as many Instances as needed, whether one, a dozen or thousands. Each Instance will have its own Schedule. So, for example, and Instance for Home Remedies could be created that begins on July 1, another can be created that begins August 1, and a third one that begins September 1. The teacher would look at the different Instances and decide which one would be more appropriate and register for that Instance (not for the Project). When creating an Instance for a Project, whoever creates the Instance can make whatever changes are required to serve the purpose, not being

limited to changing the starting date. For example, an Instance for Home Remedies could have the project description changed so the students are required to do research on Home Remedies during the Renaissance instead of interviewing their grandparents. The Project's description doesn't need to change, only that of this particular Instance (or a separate Project could be created about "Home Remedies throughout History" which describes in more details the ideas behind this variation of the Project).

Figure 3 shows the Schedule for the Home Remedies Project. When an Instance is created, the dates are adjusted to reflect calendar dates based on the starting date and the relative duration of each event in the Schedule. During the Registration Phase, the Instance is open for teachers to register. In Figure 3 the Registration is set to last 30 days, but if a group of teachers decide to run the Project with just themselves as participants, they can create an Instance, make the Registration Phase last 1 day, Register, and close the Registration by moving to the Preparation Phase. During the Preparation Phase, teachers make sure students are registered in LiveMappers, CmapTools is available and installed, groups are formed and students assigned to the groups. The Execution Phase consists of activities together with their deadlines and deliverables. During the Preparation Phase, teachers can adjust these according to their needs, changing dates (e.g. based on holidays, exams, etc.) and adding or removing Events. The last Phase is Finalization, where the Instance closes down and cannot be modified any further.

3.2 Project's and Instance's Blog and Forum

Each Project and each Instance of a Project has its own Blog and Forum. These are created automatically as new Projects or Instances are created. Teachers and students can use the Instance's Forum to discuss ideas as the Instance progresses. The Blog can be used, for example, as a historical narrative for the progression of the Instance.

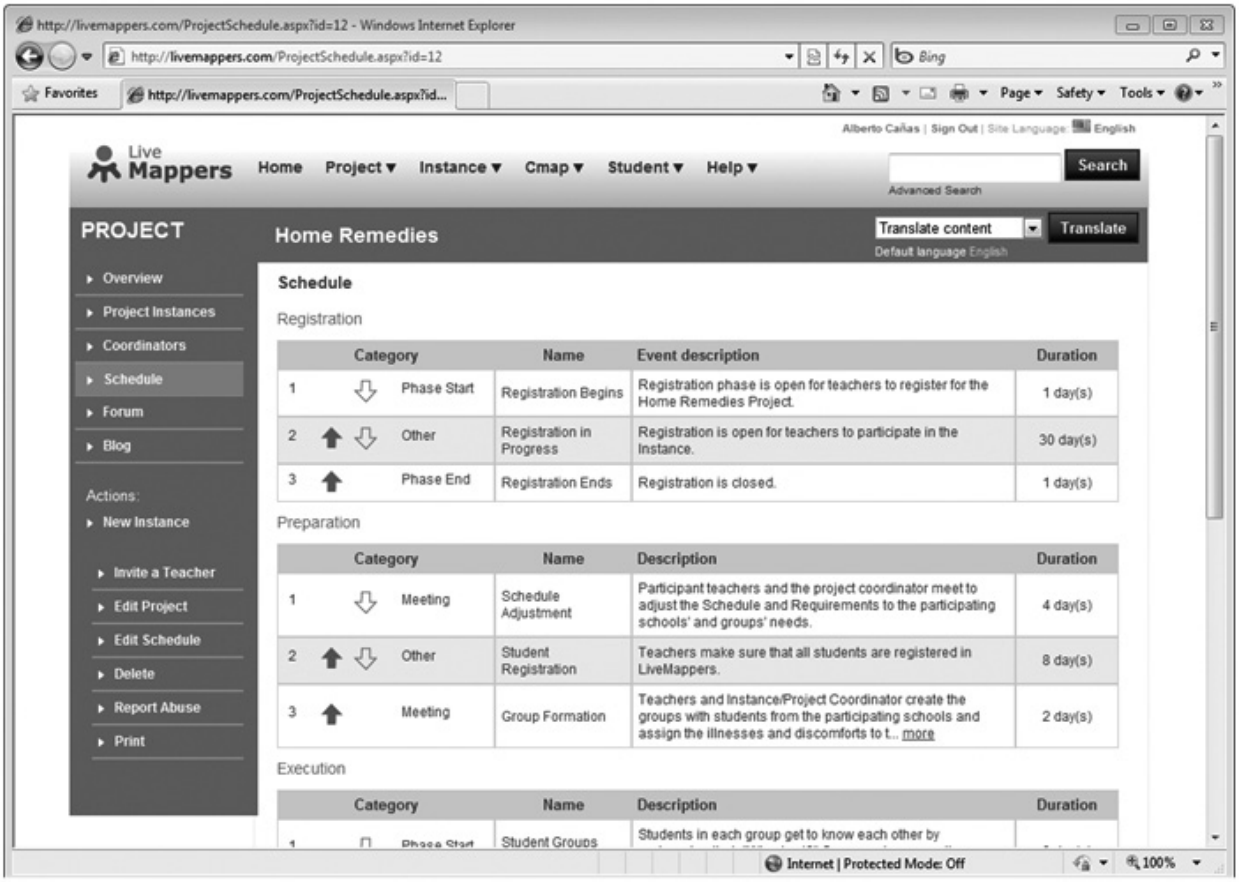


Figure 3. Part of the Schedule for the Home Remedies Project, showing the first three phases of the Project with some of the Events.

3.3 Teacher and Student's Space: Integration with a CmapServer

Each student and teacher registered in LiveMappers has their personal home page where they are presented with a summary of what is happening in Instances they are part of (e.g., a student can be in more than one Instance, e.g. from different classes, and a teacher can have several classes, each registered on a different Instance), links to the Instances, and a profile page as shown in Figure 4a. Teachers' pages have links to their students' pages, and students have links to their teacher's page. Teachers and students get assigned their own "space" to store their concept maps. This space is actually a folder in a CmapServer associated with the LiveMappers site with the appropriate permissions, as displayed in Figure 4b.

Each Instance also has its own space for concept maps (which is also a folder in the CmapServer). Within this space, each student registered in the Instance has his/her personal space (a folder), where only the student (and the teachers) has permissions to edit Cmaps and resources. A link to this folder is displayed in the student's Cmap area as shown in Figure 4b. Thus, from their concept mapping area students can get to the Instance's area, and there they can select their own folder. LiveMappers automatically creates the folder structure with appropriate permissions for the different Instances the student is registered in. The Teacher also has links to the Instances folders and therefore to the student's concept maps. If an Instance involves students participating in groups (as explained for Home Remedies above), LiveMappers creates a shared folder within the Instances' folder, for which all students that are members of the group have permissions. Permissions for shared folders are handled automatically.

3.4 Integration with CmapTools

The page that presents the concept maps and folders to the student (or teacher), as shown in Figure 4b, provides tools to manipulate these Cmaps and resources. Selecting the "Edit Cmap" entry in the pull down menu for a Cmap's thumbnail will automatically launch CmapTools and open the Cmap for editing[1]. Once the Cmap is saved, a "Reload" button on the page will reload the new thumbnail. In the same way, a "New Cmap" button allows the user to launch CmapTools with a blank canvas, and when the Cmap is saved it is stored in the appropriate folder.

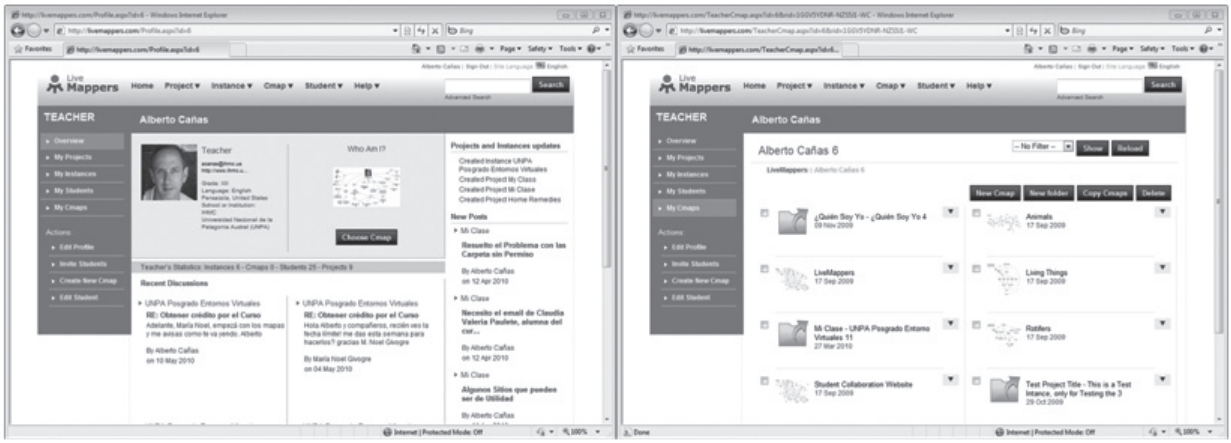


Figure 4. (a) The Teacher's Page, which includes a "Who Am I?" Cmap, and (b) View of Cmaps and links to Instances.

[1]Version 5.04 or newer of CmapTools or CmapLite is required.

With the ability to create new Cmaps and edit existing ones using CmapTools directly from LiveMappers, there is little need to go into the CmapTools Views. However, as students become more adept at using CmapTools and want to manipulate their Cmaps directly in the Views, they can open a Cmap and select the menu entry "Edit -> Find in Views" to display the Views folder where the Cmap is stored.

3.5 Implementation

LiveMappers integrates a Website with a CmapServer to store, share and publish concept maps. It is built upon Microsoft development technology, including the Live ID service. We used a layered architecture, as shown in Figure 5. On the data layer area a database implemented using SQL Server 2008, and an abstraction implemented with ADO.net Entity Framework, which facilitates the representation and access of data. The domain layer includes a transaction component, responsible to access data and deliver it to the Web site, based on the transaction script design pattern because of its simplicity (Fowler, 2002), which helped to delegate tasks. This component makes use of LINQ to Entities, a Microsoft technology which facilitates the process of querying data. The domain layer also contains the CmapServer component, responsible for consuming the CmapServer API and retrieving Cmaps from the LiveMappers CmapServer. The application layer and Web site component, implemented using ASP.net, ASP.net Ajax Control Toolkit, JQuery and also responsible to interact with Live ID Service for authentication.

The CmapServer API is the component used by the application to interact with the CmapServer. In its current form, the API rests atop a SOAP-based Web Services architecture that advertises the CmapServer services via WSDL (Cañas, et al., 2006). Exporting a WSDL description of the services makes this design particularly useful in a development environment that is capable of consuming the WSDL description and exposing the service to the programmer as if the CmapServer itself were simply an object that exposes several methods (the services).

The functionality provided by SOAP based CmapServer API is a large subset of the same functionality provided by the proprietary API that is used by the CmapTools client. With the API, the LiveMappers client can create a folder for each user that will act as a container for storing that user's resources (concept maps, images, documents, etc.).

4 Availability

LiveMappers was developed as a collaborative effort between the Institute for Human and Machine Cognition (IHMC) and the Laboratório de Tecnologia da Informação Aplicada (LTIA) of the Universidade Estadual Paulista Júlio de Mesquita Filho (UNESP) under the sponsorship of Microsoft Corporation. LiveMappers is being tested with a small number of teachers and students in order to adjust functionality and fix bugs. It is available for teachers interested in collaborating with its development. It should become operational in the second half of 2010. The interface is currently in English, Spanish and Portuguese, and an automatic translation option is available to translate displayed text. It can be accessed at www.livemappers.net.

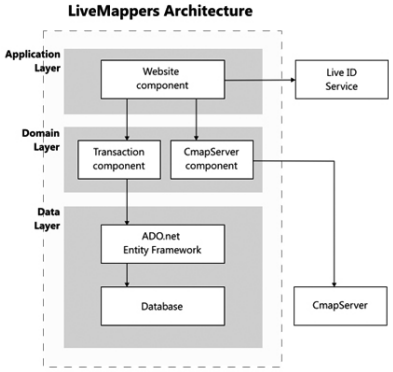


Figure 5. The implementation architecture of LiveMappers.net.

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LOS MAPAS CONCEPTUALES COMO HERRAMIENTA METODOLÓGICA PARA LA CONCEPTUALIZACIÓN DE LA RAZÓN DE CAMBIO

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Resumen. En la enseñanza de conceptos matemáticos, la comprensión y manipulación de algoritmos son procesos necesarios que deben relacionarse con contextos propios de la vida cotidiana. Por ello, es importante que los maestros incorporen en la práctica docente estrategias que ayuden a la exploración, la sistematización y la síntesis de información de manera que los estudiantes formen parte activa de los procesos de enseñanza y de aprendizaje. El estudio del concepto de razón de cambio se inicia en la educación básica con relación a disciplinas como la geometría, la economía, la física, entre otras. Los Mapas Conceptuales ayudan a los estudiantes a relacionar este concepto en términos teóricos y contextuales, permitiéndoles encontrar similitudes y diferencias interpretativas. En este artículo se presentan los resultados y conclusiones que surgen de la implementación de los Mapas Conceptuales como herramienta metodológica en el proceso de conceptualización de la razón de cambio en el trabajo de aula de clase.

1 Introducción

Comprender el concepto de razón de cambio es un elemento de la construcción del pensamiento variacional que los estudiantes de secundaria deben alcanzar en el proceso de formación matemática. En este artículo se presenta concepciones del cambio cualitativo y cuantitativo con situaciones del entorno de los participantes que conducen a la conceptualización del objeto de estudio. Las actividades propuestas en el aula de clase se apoyaron en representaciones geométricas, tabulares, algebraicas y gráficas que sustentan el desarrollo comprensivo de este concepto. Para dar cuenta de estos logros, el análisis se realizó con base en los Mapas Conceptuales como herramienta metodológica que permitió la exploración del lenguaje empleado y, la realización del seguimiento y evaluación de las relaciones conceptuales generadas por los participantes.

2 Planteamiento del problema

En la historia de las matemáticas, el descubrimiento del álgebra posibilitó la solución analítica de múltiples problemas. Se concibe como la herramienta fundamental que permite la matematización, es decir, da el valor pragmático que constituye esta ciencia. Con el álgebra se puede expresar la variación, matematizar diversas situaciones del entorno y en algunos casos proponer generalizaciones, motivando de esta forma el desarrollo del pensamiento variacional.

Este tipo de pensamiento matemático exige cambiar el paradigma en el proceso de enseñanza, pues "la labor de enseñar, y en particular, la de enseñar matemáticas, se ha caracterizado en nuestra cultura por ser una actividad que se "hace" y que no se "describe" ... lo que hace difícil su análisis y control" (Espinoza, 2000). Desde esta concepción el campo de la educación matemática debe ayudar a formar un hombre capaz de cambiar, describir, interpretar, predecir consecuencias, cuantificar, modelar; que es un resultado de las acciones que pueden ser desarrolladas en el aula, si el proceso de enseñanza y de aprendizaje se da comprensivamente, posibilitando que la matematización y el pensamiento variacional se desarrollen conjuntamente.

Con base en la premisa anterior, el trabajo de aula debe desarrollarse de tal forma que la razón de cambio se comprenda desde sus relaciones matemáticas y contextuales. Esto conduce a implementar metodologías flexibles, no transmisionistas o netamente algoritmicistas, que permitan ampliar el referente conceptual nutriendo de esta forma el pensamiento variacional, logrando que el proceso de enseñanza y de aprendizaje en el que se encuentra inmerso cada estudiante le posibilite adquirir un sentido propio y universal del objeto de estudio, para que pueda comunicar las comprensiones obtenidas en su entorno social. Además, el trabajo debe ser participativo para crear una relación

biunívoca entre los actuantes.

Desde esta perspectiva, el alumno es un sujeto que aporta a la construcción de conocimientos y a la aplicación flexible de ellos y, el maestro debe fomentar la participación activa de los estudiantes y guiarlos en la construcción de nuevos significados. Los Mapas Conceptuales fueron la herramienta metodológica que permitió establecer relaciones entre los actuantes y evaluar sus intervenciones desde la verbalización, la conceptualización y aplicación del concepto objeto de estudio.

3 Objetivo

La matematización y la relación contextual de la razón de cambio, se vinculan entre sí y son necesarias para apropiarse del concepto de forma comprensiva. Teniendo presente lo anterior, se plantea como objetivo del trabajo de aula, describir y analizar el proceso de enseñanza y de aprendizaje para la conceptualización de la razón de cambio con el propósito de determinar la viabilidad de la implementación de los Mapas Conceptuales como herramienta para la exploración, sistematización y síntesis de la información recolectada.

Es importante precisar que el análisis apunta a describir los niveles de comprensión que alcanzan los estudiantes cuando hacen uso de los Mapas Conceptuales bajo tres finalidades: ruta de aprendizaje, extracción y síntesis de significados y como evaluación (Esteban & Rendón, 2008).

3.1 Como ruta de aprendizaje

En palabras de Novak, "un Mapa Conceptual también puede hacer las veces de "mapa de carreteras" donde se muestran algunos caminos que se pueden seguir para conectar los significados de los conceptos de forma que resulten proposiciones" (Novak & Gowin, 1988). Para el docente, esto implica la "planeación del currículo" reflejado en sus prácticas, permitiendo que el alumno cuestione ¿Qué voy a aprender?, ¿Para qué me sirve lo que voy a aprender?, ¿Qué aplicaciones tiene esta temática en contexto?, entre otros aspectos (Esteban & Rendón, 2008).

En esta parte del trabajo de aula se generó un Mapa Conceptual (Figura 1.) que dio cuenta de las intenciones conceptuales y metodológicas. Se socializó con los estudiantes y se definió como punto de partida y llegada, creando la necesidad de establecer relaciones teóricas entre los conceptos referenciados en el mapa.

3.2 Para extraer significados y sintetizar

Después de tener claridad sobre el trabajo a realizar, se inició el desarrollo de actividades sobre la razón de cambio en diversas situaciones, pero fueron los Mapas Conceptuales las herramientas que permitieron a los estudiantes sintetizar los procesos realizados. Es importante anotar que los primeros trabajos presentados no se pueden catalogar como Mapas Conceptuales, sino como "mapas de relaciones", pues a partir de una idea los estudiantes no reconocían los conceptos clave sino que planteaban relaciones, complementándolas con otras más amplias, pero después de varias etapas de reelaboración adquirieron la habilidad para construir Mapas Conceptuales. Como lo afirma Novak: "En un segundo Mapa Conceptual generalmente se muestran las relaciones clave de una forma más explícita… logrando hacerlos más claros, se corrigen los errores de ortografía y se reduce la confusión y el amontonamiento" (Novak & Gowin, 1988). Este proceso dio a los estudiantes claridad para la organización cognitiva, mostrando avances en la conceptualización de la razón de cambio debido a que se construyeron proposiciones y argumentaciones a partir del lenguaje que fueron un paso previo para la comprensión del concepto desde lo matemático.

3.3 Fines evaluativos

Al final de este proyecto de aula, los estudiantes debían elaborar un Mapa Conceptual como un proceso de síntesis y realizar una exposición ante sus compañeros. El mapa debía generarse a partir de una situación real que ellos habían

seleccionado para analizar las variaciones ocurridas y determinar si existía o no una razón de cambio, describiendo los procesos involucrados en su definición.

Es evidente que el mapa en esta etapa se convierte en una herramienta de estudio que permite sintetizar las relaciones y partes más importantes del concepto abordado. Cada uno de los conceptos involucrados tiene un significado de acuerdo con el contexto en el que se desarrolló el trabajo y/o de acuerdo a las exposiciones realizadas por los estudiantes.

4 Marco Metodológico

La enseñanza de las matemáticas en la educación básica, tiene como uno de sus objetivos que el estudiante inicie el reconocimiento de fenómenos que cambian cuantitativamente y que pueden ser modelados partiendo de los conceptos previos aprendidos a lo largo de su formación académica, es decir, la razón de cambio inicia al alumno en la percepción de modificaciones que sufre su entorno y que pueden ser medidas.

La metodología participativa, se fundamenta en la convicción de que las escuelas deben comprometer a los alumnos en su propio aprendizaje y fortalecer la comprensión como habilidad central de su formación. Esto implica que el profesor debe promover acciones que conduzcan al desarrollo de habilidades de comprensión a través de actividades que sean significativas en la vida diaria de cada uno de ellos. Esta integración permite al maestro crear una ruta de aprendizaje que facilita el desarrollo de actividades que conducen a la comprensión de los significados de conceptos en el área de conocimiento en la que se aplica.

Es importante contar con recursos que proporcionen parámetros comparativos y definan el cumplimiento del objetivo propuesto. Los Mapas Conceptuales, en nuestra investigación, fueron la herramienta que permitió la indagación, la valoración y la síntesis. Su uso condujo a explorar los procesos de comprensión de los alumnos participantes en el proyecto de aula. En este sentido, para Pozueta y otros (2006), “los mapas conceptuales constituyen una herramienta inmejorable para potenciar el aprendizaje significativo (AS)” en el concepto de proporción. A continuación se describe la aplicación de los mapas conceptuales desde las tres finalidades propuestas para la conceptualización de la razón de cambio.

5 Implementación de los Mapas Conceptuales

Los Mapas Conceptuales como herramienta metodológica dieron cuenta de tres momentos definidos en el trabajo de aula. El primero de ellos responde a la ruta de aprendizaje, por lo que se construyó un Mapa Conceptual (Figura 1). que diera cuenta de la ruta que los estudiantes debían de seguir en la comprensión del concepto de razón de cambio. El Mapa Conceptual resultante se socializó con todo el grupo participante. Además, se fijo en un lugar destacado del aula de clase para que sirviera de guía y control tanto en el proceso de aprendizaje como en la evaluación.

A partir de la socialización de este Mapa Conceptual el profesor planteo a los estudiantes preguntas como: ¿Qué es un cambio?, ¿Cómo nos damos cuenta que ha ocurrido un cambio?, ¿En cuáles situaciones de la vida diaria ocurren cambios o variaciones?, ¿Cuál es la importancia del cambio?, ¿Cómo se miden los cambios?, entre otras. Estas preguntas orientaron la primera actividad del proceso de aprendizaje. Los estudiantes construyeron las respuestas a dichos interrogantes por medio de consultas y entrevistas a personas de diversas profesiones y oficios. Esta actividad permitió hacer referencias textuales de este concepto desde cualquier fuente (diccionarios, enciclopedias, internet, etc.) y situación (economía, ciencias naturales, historia, entre otras) para lograr precisar la definición sobre el concepto de cambio.

De acuerdo a lo descrito por los estudiantes y la socialización entre todos los grupos de trabajo se tomó como premisa que “el cambio es una alteración de lo común y puede ser de tipo económico, político, emocional, físico, racional, estructural, entre otras. Estas variaciones o modificaciones se perciben dependiendo del ámbito en el que se esté inmerso” (Rendón, 2009).

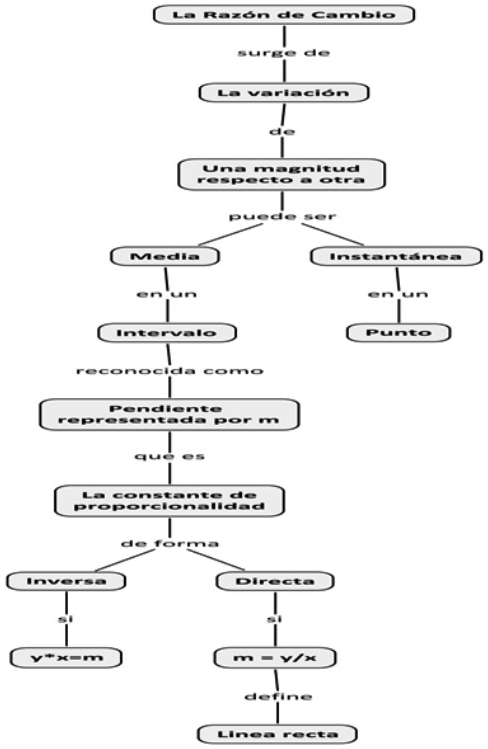


Figura 1. Mapa Conceptual utilizado como ruta de aprendizaje en el concepto de razón de cambio

Se pidió a los estudiantes que realizarán por equipos, un Mapa Conceptual que diera cuenta del trabajo realizado por fuera del aula de clase, esto permitió visualizar las concepciones asumidas sobre el tema y la conceptualización alcanzada. En estos mapas no involucraron ningún aspecto matemático que les permitiera sistematizar el cambio. Uno de los mapas realizado por un grupo de estudiantes se presenta a continuación (Figura 2).

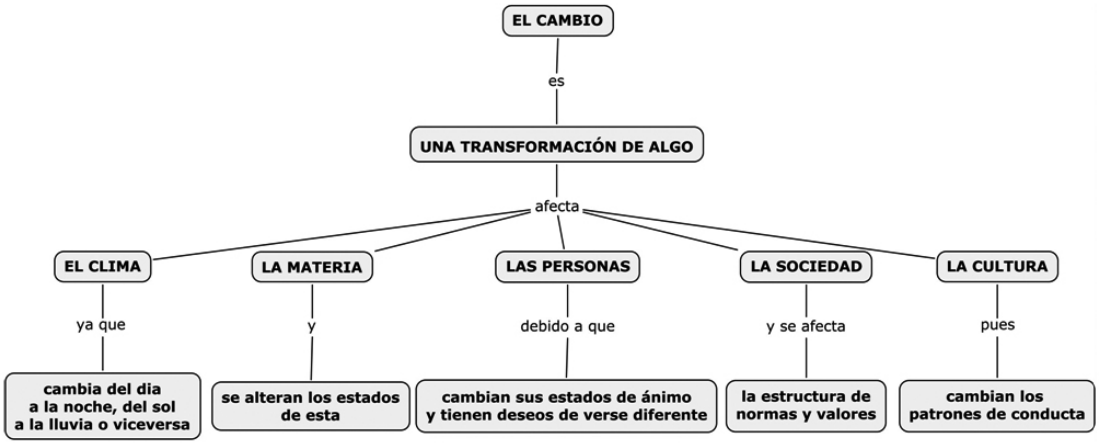


Figura 2. Mapa Conceptual presentado por un grupo de estudiantes sobre significados del cambio

En este Mapa Conceptual se recogen los principales aspectos abordados en el primer momento de intervención y es un ejemplo de la capacidad de síntesis lograda por los estudiantes. Es una evidencia de cómo las actividades realizadas direccionaron la concepción del concepto estudiado y las diferentes áreas en las que reconocieron procesos de cambio. Logran establecer un antes y después, momentos necesarios para realizar la medición de las variaciones cuantitativas. Se rescata que incluyen conceptos relevantes y establecen jerarquías entre ellos. Este mismo mapa, como herramienta evaluativa, confirmó que los estudiantes habían ganado claridad en relación al concepto de cambio y sus asociaciones con el entorno, pero no realizaban relaciones matemáticos, lo que hace necesario profundizar más en el tema, para lograr el objetivo definido.

A partir de los resultados obtenidos, se ve la necesidad de incluir actividades en que la variación se pueda medir, para vincularla con el cambio cuantitativo. Esto conlleva al manejo de registros tabulares y gráficos que dan inicio a la escritura de expresiones matemáticas, es decir, se hace uso de la modelación. Los estudiantes recopilaron el material estudiado para dar respuesta a las situaciones propuestas y a demás, las ampliaciones realizadas sobre el concepto estudiado. Se les solicito que construyeran un mapa (Figura 3), con el fin de sintetizar lo comprendido hasta ese momento del proceso. Esta actividad permitió que los estudiantes revelaran la organización cognitiva y la conceptualización que habían alcanzado con respecto a la razón de cambio.



Figura 3. Mapa Conceptual realizado por los estudiantes para presentar conclusiones sobre el tema

Al socializar y analizar los mapas, se reconoció en los estudiantes una estructuración de jerarquías más elaboradas. Ellos involucraron diferentes términos para hacer referencia al cambio y mostraron los avances obtenidos con relación a la construcción de proposiciones y argumentaciones. Los Mapas Conceptuales fortalecieron la comprensión del concepto de cambio en relación con la distinción entre el cambio cualitativo y cuantitativo. Los cambios cualitativos los perciben desde las descripciones y evidencias y los cuantitativos desde diagramas, ecuaciones y fracciones, mostrando un avance en la conceptualización del cambio desde estas dos perspectivas.

Los conceptos mencionados hacen alusión a los registros tabulares, los registros gráficos y a la representación algebraica (modelación de la situación) que son aspectos fundamentales en la formalización de la razón de cambio. Teniendo como referencia lo anterior, puede vincularse la proporcionalidad directa e inversa, las constantes de proporcionalidad, la variación de magnitudes, la representación gráfica y algebraica de la línea recta, pues son temáticas que

no se desvinculan del concepto objeto de estudio sino que, por el contrario, lo fundamentan y amplían.

Los Mapas Conceptuales se convirtieron en una herramienta evaluativa de los procesos, permitiendo a los estudiantes sintetizar las relaciones del concepto objeto de estudio y al docente, observar diferencias en la conceptualización lograda. De acuerdo a uno de los mapas realizados por los estudiantes para sintetizar y dar cuenta de lo aprendido (Figura 4), se aprecia la importancia del contexto para dar significado a la razón de cambio. Además, reconocieron los tipos de cambios que pueden darse (constante y variable) y las características que los definen y son una herramienta para determinar lo cualitativo a partir de la verbalización. Para lo cuantitativo, incluyen registros gráficos, algebraicos y procedimentales, como son las ecuaciones y las mismas razones de cambio. En esta actividad los conceptos que los estudiantes involucraron en sus construcciones, tenían un significado específico de acuerdo con el contexto en los que desarrollaron los trabajos. Ellos construyeron en el mapa formalizaciones de los procedimientos algorítmicos o procesos que les permitan llegar a respuestas correctas a partir de los conceptos y proposiciones que explican el fenómeno o la situación estudiada.

Desde esta experiencia, los Mapas Conceptuales se convierten en una herramienta importante para el docente, porque en primer lugar, le permiten reflexionar sobre su práctica pedagógica y de esta forma construir experiencias significativas para sus estudiantes; en segundo lugar, le ayudan a identificar cuando un estudiante ha construido correcta o incorrectamente las relaciones involucradas en el aprendizaje y como debe intervenir para ayudarle a progresar en su formación para que así, él pueda construir los fundamentos matemáticos de manera sólida.

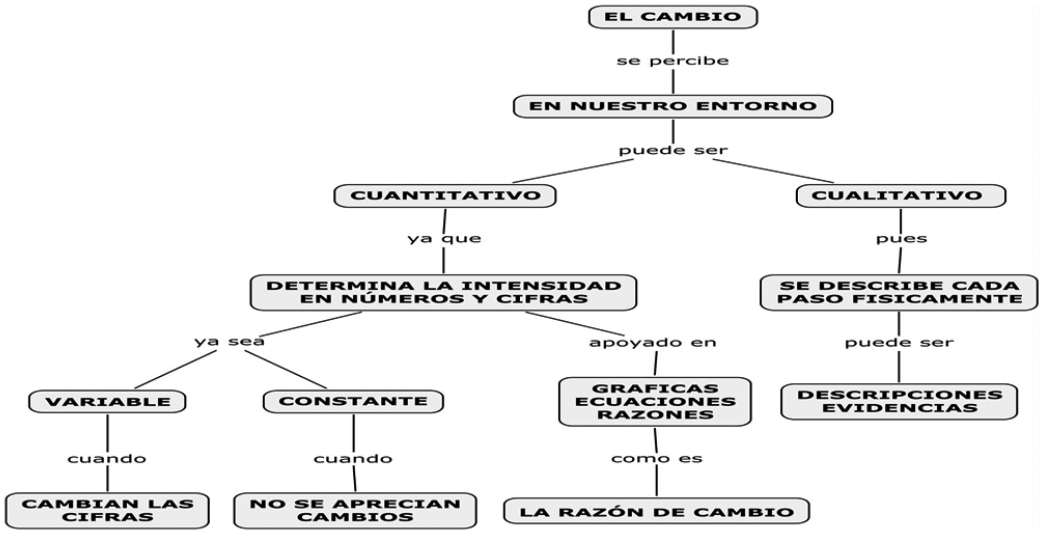


Figura 4. Mapa Conceptual realizado por los alumnos al final del proceso

6 Resultados y conclusiones

Si se concibe el proceso educativo de enseñanza y de aprendizaje como una meta en la que el alumno logre un aprendizaje de los conceptos expuestos, que expanda y articule su red de relaciones y pueda aplicarlos en diferentes contextos, se hace necesario que el docente involucre herramientas que dinamicen las actuaciones de los agentes que participan en la construcción del nuevo conocimiento. En nuestro caso, la aplicación en el aula de clase de los Mapas Conceptuales, permitió que los alumnos se mostraran más motivados a realizar las actividades propuestas y a ser partícipes en la construcción de su propio conocimiento.

En la experiencia se partió de los conocimientos previos de los estudiantes, permitiéndoles el desarrollo de competencias matemáticas descentradas de lo algorítmico, potenciando habilidades propositivas y argumentativas que se complementaron con otras que les permitieron expresar de manera creativa sus ideas, asociando de esta manera el concepto estudiado con fenómenos de su entorno que cambian cuantitativamente.

Los Mapas Conceptuales, permiten identificar a lo largo de la experiencia, que los estudiantes alcanzaron con relación a su nivel de escolaridad, una adecuada conceptualización de la razón de cambio, pues la reconocen como el cociente de dos magnitudes y logran realizar registros tabulares a partir de cálculos proporcionales, asociando las respuestas obtenidas con la pendiente de una línea recta.

En entrevistas personales, los estudiantes afirman que la forma de trabajo llevada a cabo fue creativa, que se les permitió utilizar recursos que estaban a su alcance. La construcción de Mapas Conceptuales fortaleció su red de relaciones. Se utilizaron como ruta de aprendizaje, para extraer significados y/o sintetizar y con fines evaluativos, permitiendo orientar los diferentes procesos de aprendizaje y de enseñanza, sirvieron como insumo para determinar el nivel de compresión que lograron los estudiantes al finalizar el proceso. Además, la participación en exposiciones y trabajos en grupo fomento sus habilidades propositivas y argumentativas, creando un ambiente propicio para la comprensión de la razón de cambio.

El hecho de que los alumnos sean los protagonistas, impone una disminución de los contenidos del currículo en beneficio de los procesos constructivos que facilitaron la conceptualización en lugar de la algoritmia. Esto permitió que existiera una motivación diferente respecto a los procesos de enseñanza y aprendizaje. Los procesos de aprendizaje de los alumnos se ven fuertemente influenciados por la interacción que se da en el aula de clase. Es en la discusión de los grupos, donde surgen las mejores interpretaciones y conclusiones entre los alumnos e incluso donde el profesor encuentra mejores elementos para promover el análisis. Gracias al ambiente de aprendizaje, los Mapas Conceptuales y el tipo de actividades propuestas, se logró un clima favorable para la construcción conceptual a partir de la participación y negociación de significados.

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LOS MAPAS CONCEPTUALES UNA ESTRATEGIA PARA MEJORAR EL PROCESO DE ENSEÑANZA APRENDIZAJE DE LA NEUROANATOMÍA

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Abstract. Introducción: El presente trabajo expone la implementación del uso de los mapas conceptuales como una estrategia pedagógica que propenden por transformar al alumno pasivo – receptor en activo constructor. El objetivo fue medir la mejora del rendimiento académico de los estudiantes al implementar la estrategia de los mapas conceptuales. Material y Método: Se realizo un estudio observacional en el año 2006 en Bucaramanga, Santander. El estudio se realizo en los estudiantes que cursaban la asignatura morfofisiologia II, la cual corresponde al contenido de neuroanatomía. Participaron 130 estudiantes que cursaban la asignatura en la carrera de medicina en la universidad industrial de Santander. Se implemento la metodología tradicional de clases magistrales durante todo el periodo académico y en el sistema evaluativo consistente en 4 cortes. En el tercer corte los estudiantes realizaron mapas conceptuales correspondientes a los temas que serian evaluados en el tercer corte. Las comparaciones múltiples corregidas se realizaron utilizando la prueba de Bonferroni ($p<0.05$) cuando los ANOVA indicaron diferencias estadísticamente significativas. Resultados: Todos los estudiantes recibieron clases teóricas como un solo grupo. Para otras actividades, fueron divididos en 4 grupos; A, B C y D, con 36, 40, 25 y 29 estudiantes respectivamente. Es de interés destacar que el desempeño en el parcial 3 fue muy homogéneo, no existiendo las claras diferencias atribuibles al mejor grupo (Grupo B). Un ANOVA de medidas repetidas para la comparación de los 4 parciales incluyendo todos los estudiantes mostró diferencias significativas ($F3,387: 39,116$, $p<0,001$) donde las comparaciones múltiples con Bonferroni indicó que: Las calificaciones del tercer parcial fueron significativamente mayores que las de los otros parciales. Discusión: La realización de mapas conceptuales en forma cooperativa reafirma que el conocimiento se construye en forma activa a partir de un conocimiento previo. Lo cual se vio reflejado en la mejoría del rendimiento académico con el uso de los mismos.

1 Introducción

En la escuela de medicina de la Universidad Industrial de Santander (UIS), Colombia, la enseñanza de la anatomía y la fisiología se imparte en el primer año de la carrera con las asignaturas Morfofisiología I y II, en su metodología se utilizan la clase magistral y las prácticas de laboratorio. Estas incluyen el estudio de estructuras anatómicas en especímenes cadavéricos. En estas materias, usualmente resulta una alta tasa de reprobados 18 al 24%.

A pesar que la conferencia magistral ha mostrado su efectividad en la trasmisión de contenidos ya elaborados (Hudson & Buckley,2004), es una actividad que tiene dentro de sus debilidades el estar centrada en el profesor y dirigida por él, con la escasa participación de los alumnos, quienes como espectadores se limitan a tomar apuntes y a consultar algunas dudas. Para romper este esquema se han desarrollado en algunas universidades, a nivel mundial, experiencias innovadoras de tipo participativo que han mostrado su eficacia sobre esta metodología tradicional (Gal-Iglesias et al, 2009; Inzunza,Vargas & Bravo, 2007).

En la UIS, Colombia, estos planteamientos tan discutidos, han generado en los profesores encargados de los procesos de enseñanza aprendizaje de la anatomía, una revisión crítica de sus prácticas pedagógicas, apoyados en la investigación educativa, de manera que se puedan superar aquellos obstáculos que impiden la formación integral y el aprendizaje significativo de sus estudiantes(Ayala-Pimentel, Diaz-Perez & Orozco-Vargas, 2009). Los procesos de cambio han incluido la reorientación de las actividades de enseñanza en el aula, con el uso de herramientas de carácter constructivo y dialógico que permitan renovar la metodología "transmisionista".

Una de las estrategias formativas utilizadas para apoyar los procesos de enseñanza, orientada a lograr aprendizajes significativos y duraderos son los mapas conceptuales, definidos como la representación visual, lógica y coherente de la estructura cognitiva de un individuo relacionada con el conocimiento de un argumento preciso (Hernandez, 2007). Están constituidos por tres elementos básicos: los conceptos que corresponden a una palabra o una frase nominal muy breve que se emplea para designar objetos, ideas o eventos que generalmente se colocan dentro de un círculo; las palabra de enlace que unen los conceptos y señalan los tipos de relación existente entre ambos y las proposiciones

que corresponden a unidades semánticas constituidas por dos o más términos conceptuales ligados por una palabra o mas palabras de enlace (Figura1).

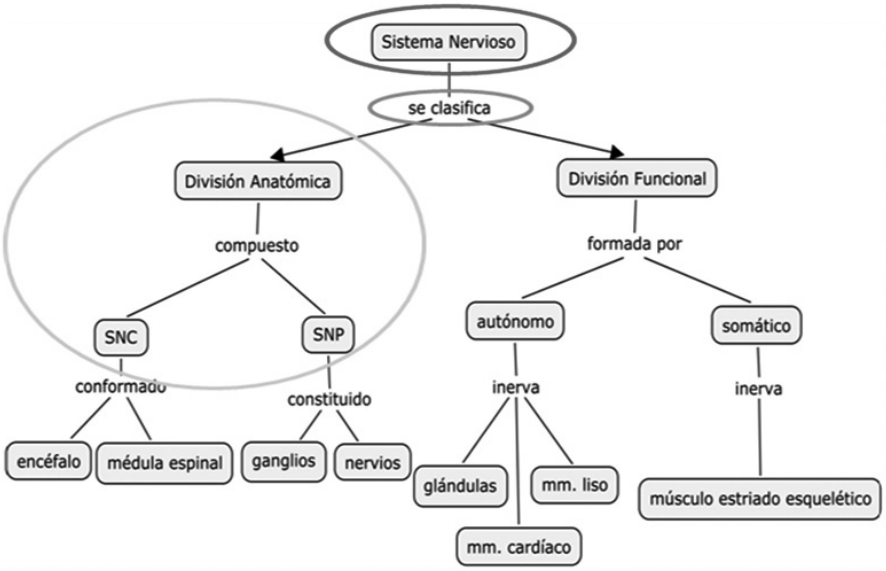


Figura 1. Elementos que constituyen una proposición: Conceptos o términos conceptuales y las palabras de enlace

Los mapas conceptuales poseen características como: a) la jerarquización, que consiste en que los conceptos están organizados por orden de inclusividad, ya sea por diferenciación progresiva o reconciliación integradora; b) la simplificación, que exige selección para que sean la síntesis de lo más significativo de un tema de estudio; y c) el impacto visual, que implica que un mapa conceptual debe mostrar en forma clara, concisa y vistosa los conceptos y las relaciones entre éstos. (Cañas et al, 2003).

El objetivo del presente trabajo fue evaluar el cambio en el rendimiento académico de los estudiantes que cursaban la asignatura morfofisiología I, con la implementación del uso de los mapas conceptuales para el estudio los distintos componentes del sistema nervioso.

2 Material y Método

Diseño Del Estudio

El presente es un estudio de diseño experimental, fue llevado a cabo durante el segundo periodo académico del año 2006 en las secciones de morfología y fisiología de la escuela de medicina de la UIS, Colombia, Sur América. En él se intervino un grupo de estudiantes con la metodología de mapas conceptuales, hubo igualdad en el nivel formativo de los docentes y de la intensidad horaria para el desarrollo del curso. Los investigadores participaron en el diseño, evaluación, análisis y redacción del manuscrito.

Participantes

Participaron 130 estudiantes de segundo semestre de la carrera de medicina de la Universidad industrial de Santander quienes cursaban la asignatura morfofisiología I que corresponde al tópico de anatomía funcional de los sistemas neuroendocrino, inmunitario y reproductor masculino y femenino.

Metodología

Las actividades realizadas durante el semestre consistían en cinco encuentros teóricos semanales, dos de trabajo práctico en el anfiteatro y uno en el laboratorio de histología, cada uno con una duración de dos horas, durante las dieciséis semanas del curso. Las clases teóricas las recibieron como un solo grupo y para efectos de prácticas de laboratorio y otras actividades, fueron divididos en 4 grupos; A, B C y D, con 36, 40, 25 y 29 estudiantes respectivamente. El sistema evaluativo consistió en cuatro exámenes teórico – prácticos, uno cada cuatro semanas, con pruebas de preguntas de selección múltiple y de identificación de estructuras macro y microscópicas referentes a los temas estudiados en cada periodo del semestre.

Los temas abordados en los tres primeros cortes se relacionaba con la anatomía funcional del sistema nervioso, mientras que los tratados en el cuarto corte hacían referencia a los sistemas endocrino, inmunitario y aparatos reproductores masculinos y femeninos.

Primero, Segundo y Cuarto Cortes, la intervención para el tercer corte

La metodología utilizada en el aula de clase, durante esta parte del curso, consistió en el uso de la conferencia magistral, en la que el profesor, mediante la utilización de ayudas audiovisuales, explicaba el tema a desarrollar.

Para el desarrollo del tercer corte del programa se tuvo en cuenta como estrategia de trabajo, los mapas conceptuales. El trabajo se llevó a cabo en tres etapas, así:

- Primera Etapa: El primer día de clase de este corte se explicó a los estudiantes el significado, las características, los propósitos y la forma de construir los mapas conceptuales (Novak & Cañas, 2008). Se hizo énfasis que antes de la elaboración del mapa es fundamental la consulta en textos para comprender mejor acerca de los conceptos fundamentales del tema, reflexionar sobre las relaciones existentes entre ellos y las que podían establecer con las concepciones previas. Se explicó la diferencia que tiene el mapa conceptual con un esquema o un diagrama, para que no se llegasen a presentar simplemente secuencias lineales de acontecimientos, de datos o de hechos. En esta etapa se solicitó la conformación de grupos de cinco estudiantes.

- Segunda Etapa: Esta etapa tiene tres momentos. Un primer momento, en el que el profesor expone el tema a tratar en forma concisa y breve y explicaba la metodología a tratar en la clase, que podía ser:

1. Entregar una lista de los conceptos sobre la cual se trabajaba.
2. Suministrar mapas incompletos, que en ocasiones incluían con errores, para ser reelaborados.
3. Identificar un listado de conceptos para construir su versión de mapa conceptual.

Un segundo momento, en el que los estudiantes reunidos por grupos leían en distintas fuentes bibliográficas, analizaban, discutían y organizaban sus ideas para realizar el trabajo propuesto. En el último momento, se socializaban los resultados en sesión plenaria, se resolvían dudas, se clarificaban ideas, y se enriquecían los trabajos con los aportes de los otros grupos. En este momento el profesor completaba la explicación con la ayuda del proyector de diapositivas e inducía a la reflexión sobre el proceso seguido.

- Tercera Etapa: En esta última parte del proceso, denominada de trabajo independiente, el estudiante analizaba y evaluaba su trabajo realizado en clase y elaboraba el informe final que consistía en la entrega de tres a cinco mapas de acuerdo con la contenido temático abordado.

Evaluación de la eficacia

En la evaluación de la eficacia de la adquisición de aprendizaje fue utilizado en los tres cortes un examen de 50 preguntas de selección múltiple, de única respuesta, con 4 distractores, para aprobar el examen los estudiantes debían contestar acertadamente 30 preguntas. Este examen fue evaluado previamente por parte de expertos en la materia recibiendo su aprobación.

Análisis

El rendimiento académico se evaluó mediante las calificaciones teórico-prácticas de los exámenes de cada corte.Se realizaron cálculos de estadística descriptiva para la calificación de cada corte (promedio, desviación y error estándar, etc. (Tabla 2) y distribuciones de frecuencias absolutas, relativas y acumuladas.

Las comparaciones entre las calificaciones de cada corte se realizaron mediante ANOVA para medidas repetidas seguidas de pruebas de Bonferroni para comparaciones múltiples corregidas cuando el ANOVA mostró diferencias significativas. Los cálculos estadísticos se realizaron utilizando Excel y Sigmastat 2.5.

3 Resultados

Se evaluaron 130 estudiantes que recibieron clases teóricas como un solo grupo. Para efectos de prácticas de laboratorio y otras actividades, fueron divididos en 4 grupos; A, B C y D, con 36, 40, 25 y 29 estudiantes respectivamente. (Tabla 1).

	GRUPO A	GRUPO B	GRUPO C	GRUPO D	TOTAL
HOMBRES	13	17	16	18	64
MUJERES	23	23	9	11	66

Tabla 1. Distribución por género y grupos de los estudiantes

Eficacia

Se evaluó el desempeño de los grupos frente a cada previo teórico cuyos promedios y desviaciones estándar se incluyen en la Tabla 2. En los resultados de ANOVA Hubo diferencias entre grupos dentro de los parciales 1, 2 y 4 ($F_{3,129}$: 5.732, 4.434 y 4.748 respectivamente, p: 0.001, 0.005 y 0.004 respectivamente) no habiendo diferencias significativas entre grupos dentro del parcial 3 ($F_{3,129}$:1.699, p: 0.171).

GRUPO	N	PT1	PT2	PT3	PT4
A	36	2.656 (0.558)	2.622 (0.539)	3.303 (0.587)	2.875 (0.835)
B	40	3.112 (0.516)	2.867 (0.592)	3.502 (0.554)	3.407 (0.59)
C	25	2.776 (0.551)	2.44 (0.668)	3.22 (0.603)	3.184 (0.602)
D	29	3.052 (0.537)	2.928 (0.507)	3.234 (0.635)	2.821 (0.931)
TODOS	130	2.908 (0.568)	2.731 (0.598)	3.333 (0.596)	3.086 (0.782)

Tabla 2. Promedio ± 1 desviación estándar de la media de los parciales teóricos según grupos

Las comparaciones múltiples corregidas se realizaron utilizando la prueba de Bonferroni ($p<0.05$) cuando los ANOVA indicaron diferencias estadísticamente significativas. Es de interés destacar que el desempeño en el parcial 3 fue muy homogéneo, no existiendo las claras diferencias atribuibles al mejor grupo (Grupo B). La Tabla 3 representa las diferencias entre los grupos dentro de cada parcial.

GRUPOS	PT1				PT2				PT3				PT4			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
A																
B																
C																
D																

Tabla 3. Filas y columnas se refieren a los grupos. Las áreas sombreadas dentro de cada fila representan que el grupo de la fila fue significativamente mayor que el grupo correspondiente a la columna. Por ejemplo: El grupo B (Ver fila) fue mayor que el grupo A en el primer corte, mayor que el C en el segundo y mayor que A y D en el cuarto corte

Un ANOVA de medidas repetidas para la comparación de los 4 cortes incluyendo todos los estudiantes mostró diferencias significativas ($F_{3,387}$: 39.116, $p<0.001$) donde las comparaciones múltiples con Bonferroni indicó que: Las calificaciones del tercer parcial fueron significativamente mayores que las de los otros parciales. La del parcial 4 fue mayor que las de 1 y 2 y la del primero fue mayor que la del segundo. (Tabla 4 y Figura 2).

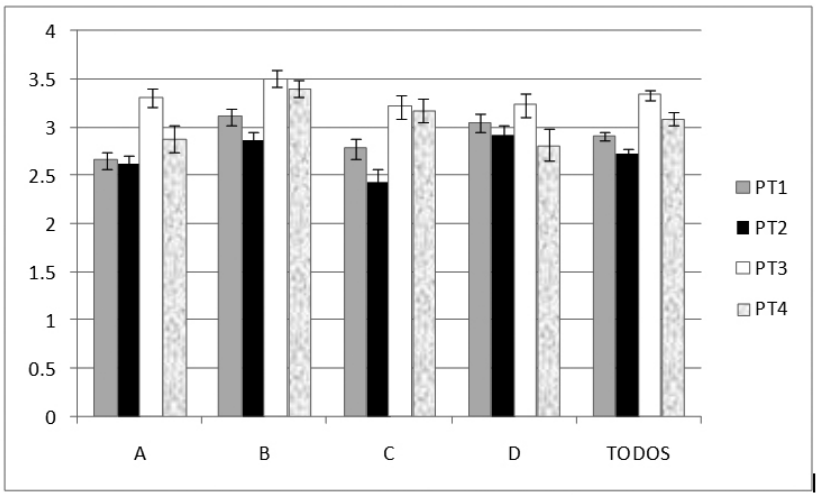


Figura 2. Representa los promedios ± errores estándar del promedio de los diferentes parciales. Para identificar las diferencias significativas ver el texto

Comparaciones	Dif medias	t	P
PT3 vs. P2T	0.602	10.354	<0.001
PT3 vs. PT1	0.425	7.313	<0.001
PT3 vs. P4 T	0.247	4.245	<0.001
PT4 vs. PT2	0.355	6.109	<0.001
PT4 vs. PT1	0.178	3.068	0.014
PT1 vs. PT2	0.177	3.041	0.015

Tabla 4. Resultados obtenidos con la prueba de Bonferroni con las comparaciones entre los parciales incluyendo todos los participantes

En la Tabla 5 y en la Figura 3 se observa la comportamiento de los estudiantes a través de los parciales por rangos de notas.

RANGO	PT1		PT2		PT3		PT4	
	Frecuencia	*% acumulado*	*Frecuencia*	*% acumulado*	*Frecuencia*	*% acumulado*	*Frecuencia*	*% acumulado*
0.45	0	0.00%	0	0.00%	0	0.00%	3	2.31%
0.95	0	0.00%	0	0.00%	0	0.00%	0	2.31%
1.45	0	0.00%	2	1.54%	0	0.00%	0	2.31%
1.95	6	4.62%	13	11.54%	2	1.54%	2	3.85%
2.45	25	23.85%	22	28.46%	6	6.15%	13	13.85%
2.95	40	54.62%	49	66.15%	24	24.62%	31	37.69%
3.45	38	83.85%	27	86.92%	42	56.92%	41	69.23%
3.95	17	96.92%	15	98.46%	32	81.54%	22	86.15%
4.45	4	100.00%	2	100.00%	21	97.69%	18	100.00%
5	0	100.00%	0	100.00%	3	100.00%	0	100.00%

Tabla 5. Porcentaje de rangos acumulados de los cuatro cortes

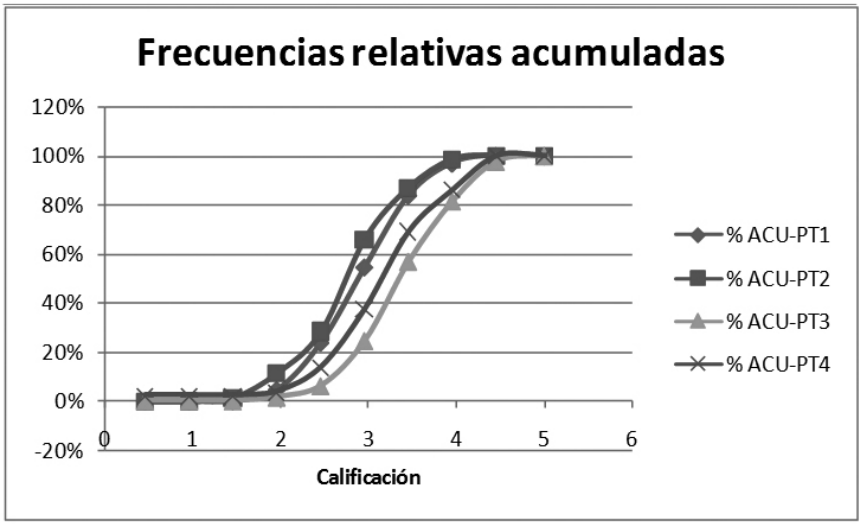


Figura 3. Porcentaje acumulado de los cuatro cortes

4 Discusión

Siempre ha existido la inquietud sobre la manera de abordar temas complejos en educación médica, como la neuroanatomía. En la escuela de medicina de la UIS se ha trabajado en implementar nuevas estrategias que permitan generar conocimiento y aprendizaje significativo, junto con la mejoría del rendimiento académico.

Es importante proporcionar estrategias que permitan mantener la motivación y generar reflexión por parte de los estudiantes. De tal forma que el conocimiento aprendido se consolide y se llegue al aprendizaje significativo con menor esfuerzo.

Los mapas conceptuales son una estrategia pedagógica que propende por transformar al alumno pasivo – receptor en activo constructor y al docente transmisor en mediador, favorecedor y facilitador del aprendizaje. En el presente trabajo se evidencio que la utilización de los mapas conceptuales como estrategia para la mejora del rendimiento académico de los estudiantes de medicina, es una herramienta útil y efectiva, independiente del tema abordado.

Otros autores han propuesto utilizar los mapas conceptuales para afianzar conocimientos en el área de ciencia

básicas específicamente en la histológica, donde los proponen como una herramienta sin embargo no cuantificaron la eficacia de su aplicación, en nuestro trabajo se cuantifica bajo el parámetro del rendimiento académico la utilidad del uso de esta herramienta en la escuela de medicina. (Sanchez-Quevedo et al, 2006).

En la ciudad de Bucaramanga es de interés común para todoas las facultades de medicina la implementación de nuevas estrategias de enseñanza. En otra institución de la ciudad con facultad de medicina UNAB, se realizo un estudio ramdomizado controlado en estudiantes de tercer semestre de medicina de la UNAB. La intervención consistió en sesiones de aprendizaje basado en problemas donde en una ellas se utilizaron los mapas conceptuales, sus resultados no fueron significativos, sin embargo al igual que nuestro trabajo l a intención es cuantificar la eficacia de la aplicación de nuevas estrategias de enseñanaza-aprendizaje. (Gonzalez et al, 2008).

En nuestro trabajo se utilizaron los mapas conceptuales como pilar en la formación y estructuración del conocimiento. Se pudo observar una mejoría en el rendimiento académico a partir de la intervención en el tercer corte, en los estudiantes de todos los grupos. Se observo que el rendimiento académico de todos los estudiantes mejoro, aun cuando sus rendimientos individuales no son parejos todos mejoraron en el tercer corte con respecto a los dos primeros. Es de destacar que en el ultimo corte aun cuando el tema evaluado no correspondía al tema de neuroanatomía, el rendimiento académico de los estudiantes fue mejor que en los dos primeros cortes.

Es importante resaltar que en nuestro trabajo se cuantifico a través del rendimiento académico, la eficacia de la utilización de los mapas conceptuales. No solo como herramienta para la enseñanza-aprendizaje de la neuroanatomía, si no de cualquier tema desarrollado. Ya que independiente de que el tema del cuarto corte no era de neuroanatomía el rendimiento académico mejoro con respecto a los dos primeros cortes.

Los mapas conceptuales como estrategia para la mejora del rendimiento académico de los estudiantes de medicina no había sido utilizada previamente, esta aplicación es innovadora. En la literatura revisada no se encontraron donde se visualice la utilización de esta estrategia. Consideramos que es una herramienta útil en la enseñanza-aprendizaje y en el proceso de conversión de estudiante hacia un sujeto que interactúa, aporta y construye su aprendizaje.

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Viña del Mar, Chile, 2010

MAPA DE RUTA ACTUAL DE LA ALFABETIZACIÓN: TICD EL TRATAMIENTO DE LA INFORMACIÓN Y LA COMPETENCIA DIGITAL O ENSEÑAR A LEER, ESCRIBIR Y PUBLICAR EN EL SG. XXI

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Abstract. Nada mas comenzar el nuevo siglo se ha desencadenado una autentica revolución comunicativa. La web 2.0 ha cambiado casi todo: la forma de ver y entender Internet, la manera de relacionarse las personas en el ciberespacio, la política, la escuela... Pero ¿ha cambiado la forma de ser analfabeto o la manera alfabetizarse? Este artículo pretende poner algunos puntos sobre las íes de la educación, de la universidad, de los institutos... para no perder el rumbo en el ancho mar de las nuevas aplicaciones y servicios que podemos encontrar en la red, continuamente re-inventados. Saber leer, escribir y publicar son claves. Category: Formal Paper.

1 Introducción

Las bases de la alfabetización podemos fijarlas en saber leer y escribir, comprendiendo el contexto en el que se encuentra la personas. Hoy en día, en el nuevo siglo, solo podemos pensar que la persona, alfabetizada o no, va a encontrarse con una red omnipresente, que en el mejor de los casos, facilita y amplifica sus posibilidades comunicativas: Internet. Como resumía el profesor Adell en las Jornadas de Educación digital (JEDi) en Deusto, "tenemos que educar para vivir en un mundo lleno de TICs" (ver imagen).



Podemos fijar que las bases de la "nueva" y actual alfabetización en saber leer, escribir y publicar en Internet, que ya forma parte de nuestra vida cotidiana; es decir comunicarse con medios personales y tecnológicos que incluyan la red como un medio más. Esta idea se expresa en el mapa de la Figura 1 "los 3 usos básicos".

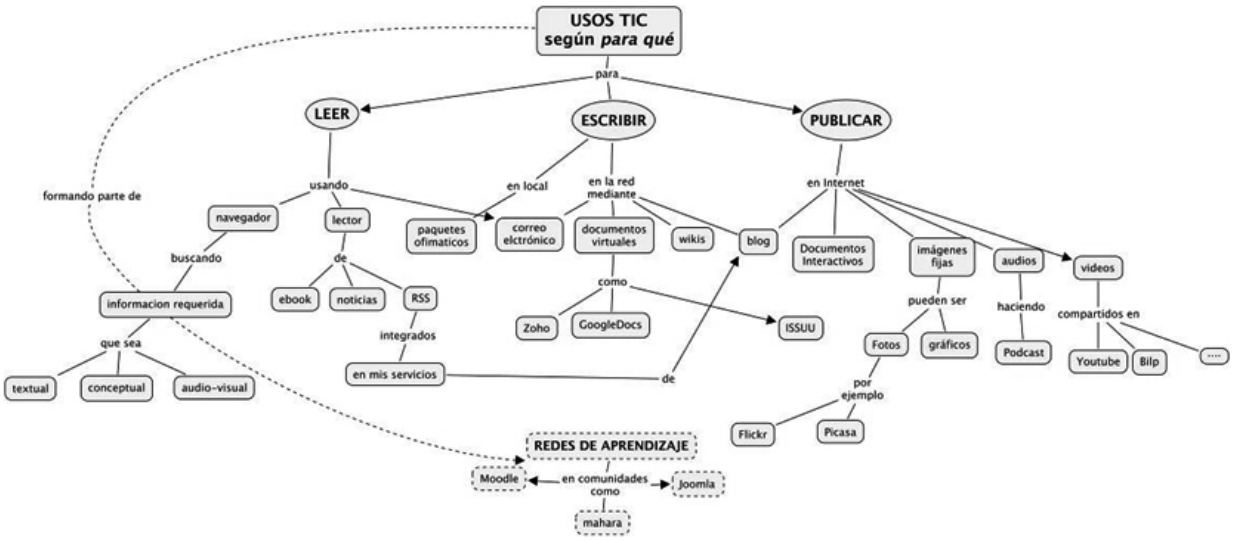


Figura 1. Los 3 usos TIC básicos para una persona alfabetizada: leer, escribir y el novedoso publicar

2 TICD: ¿De qué estamos hablando?

La primera tarea que vamos a abordar es intentar definir que es una alfabetización que incluya la competencia digital, recorriendo las diferentes formas que ha habido de entender el termino alfabetizar; y paralelamente que era una persona analfabeta. La UNESCO (1958) establece que "una persona alfabetizada es aquella que puede leer y escribir comprendiendo, una oración simple relacionada con la vida cotidiana."

Esta definición se ha ido precisando hasta acordar que "alfabetización es la habilidad para leer con comprensión una oración simple, relacionada con la vida cotidiana. Involucra un continuo de destrezas de lectura, escritura y con frecuencia, también incluye destrezas aritméticas elementales." (UNESCO 2000).

Asumiendo la idea de alfabetización como un objetivo de desarrollo sociocultural, fueron muchas las instituciones que adoptaron esta idea, adjetivándola según su campo de trabajo: audiovisual, jurídica, cultural, informacional, científica, informática, emocional, visual, de adultos, etc. De entre ellas destacaremos las más relacionadas con la escuela y el desarrollo de las TIC, viendo el origen y evolución de las diferentes maneras de enfocarla, en un breve repaso por sus conceptualizaciones: Comunicación AV, Alfin y TIC.

2.1 La alfabetización en comunicación audiovisual -CAV- (Media Literacy o Éducation aux médias)

Pretende aportar instrumentos de análisis crítico a los estudiantes, para que puedan decodificar los mensajes de los medios de comunicación, la radio, la televisión del cine o la publicidad, no quedándose en un aspecto receptivo únicamente; sino posibilitar que el estudiante pueda ser creador o productor de mensajes en los distintos medios y lenguajes: que pueda ser emisor también.

En su desarrollo destacan la Declaración de Grünwald (1982), el seminario de la UNESCO celebrado en París (2007) "L'education aux medias" que propone la "Agenda de París", la aportación del British film institute y el UK film Council (2006) fijando en 7 las destrezas básicas para garantizar la alfabetización en Comunicación AV, y la directiva europea sobre servicios AV (2007/65/EC) del 2007.

Este proceso se plasma en la Resolución del Parlamento Europeo sobre la alfabetización de los medios de comunicación en un mundo digital (2008/2129(INI)) que dice "la alfabetización mediática implica poseer las capacidades para utilizar de forma autónoma los distintos medios de comunicación, para comprender y valorar críticamente los diversos aspectos de dichos medios y sus contenidos, así como para comunicarse incluso en contextos variados y crear y difundir contenidos en los medios de comunicación; constata que, dada la multiplicidad de fuentes disponibles, lo esencial es la capacidad de filtrar certeramente y ordenar la información obtenida a partir del torrente de datos e imá-

genes de los nuevos medios de comunicación."

Joan Ferrés (2007) concreta una propuesta definiendo las 6 dimensiones y los indicadores para la competencia en CAV, concretando así esta competencia: "la capacidad de un individuo para interpretar y analizar desde la reflexión crítica, las imágenes y los mensajes AV, y para expresarse con una mínima corrección en el ámbito comunicativo." Está relacionada con el conocimiento de los medios y con el uso de las tecnologías multimedia necesarias para producirla, y se recoge en la Figura 2.

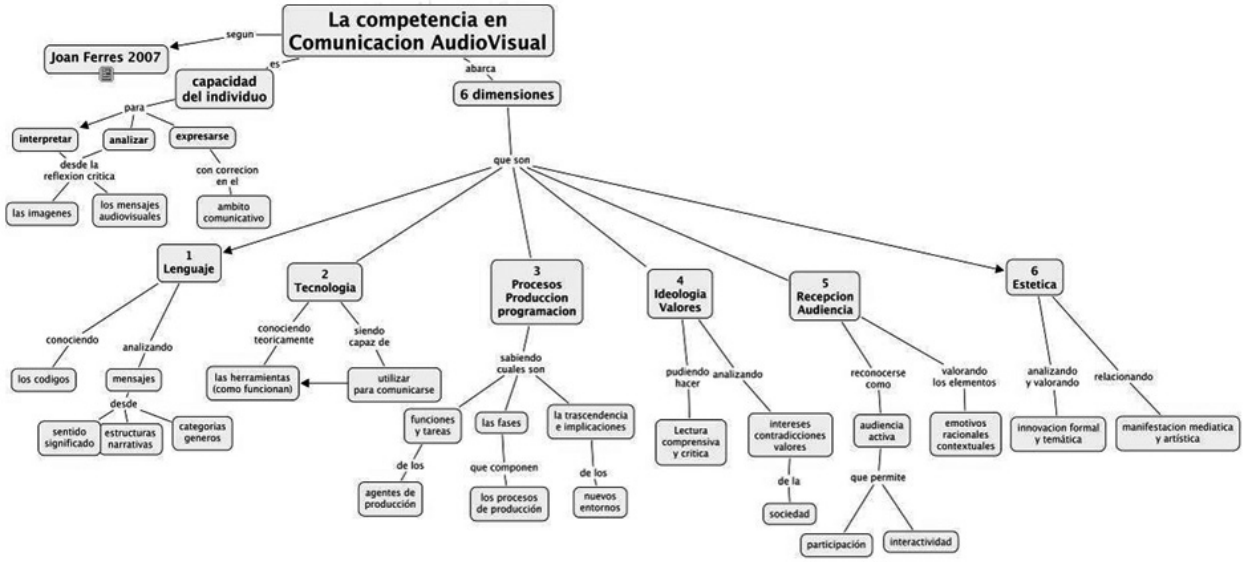


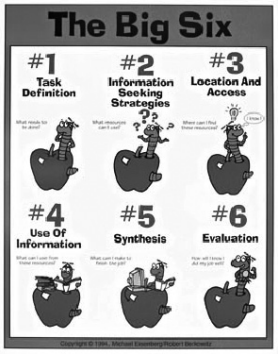
Figura 2. Dimensiones que Joan Ferrés asigna a la competencia en CAV, como capacidad para desenvolverse en el ámbito comunicativo

2.2 La alfabetización informacional (Alfin, Information Literacy, Formist)

Su núcleo de trabajo se centra en las habilidades para el tratamiento de la información, es decir la búsqueda, la selección, el procesamiento y la comunicación de la información con el objetivo de transformarla en conocimiento.

Paul Zurkowski en 1974 introduce la idea de Information Skills, y varios encuentros internacionales, aportan avances significativos: la Declaración de Praga (2003), "Hacia una sociedad alfabetizada en información", la Declaración de Alejandría (2005) centrada en la alfabetización informacional y el aprendizaje a lo largo de la vida (life long learnig), o el Seminario de trabajo de Toledo (2006) denominado Biblioteca, aprendizaje y ciudadanía.

Basándose en el desarrollo de estas habilidades, en Estados Unidos se propone la conocida estrategia BIG6 para la educación obligatoria (que vemos resumida en la imagen adjunta), mientras que la fundación Gabriel Piedrahita Uribe propone el modelo Gavilán; y la Ontario School Library Association (OSLA) presenta la Alfin como un nuevo área de conocimiento a desarrollar en toda la educación obligatoria (K12).



2.3 La alfabetización TIC (Computer Literacy)

Originaria en el ámbito anglosajón, comenzó llamándose alfabetización informática, pretendiendo en los años 80 que la gente conociera los ordenadores y tuviese nociones de lenguajes de programación. Posteriormente se habló de informática de usuario, para aprender a usar programas de ofimática, y con el nuevo siglo, planteó el uso del correo electrónico y los navegadores de Internet. las TIC.

Merecen mencionarse las aportaciones de la UNESCO y su currículo TIC, propuesta pensada para la secundaria desarrollada por el grupo de trabajo IFIP (International Federation for Information Processing) en el 2002; el ICDL/ ECDL con el Certificado Internaciona/Europeo de la Informática de usuario; el B2I o Brevet Informatique et Internet (Francia 2000); la competencia básica en TIC realizada por el Dep. D'enseñament de la Generalitat de Catalunya (2000); y la Alfabetización TIC en PISA el programa de la OCDE que estableció criterios e instrumentos de evaluación de las competencias de los adolescentes, entre las que estaban las TIC, definiendo la AlfaTIC (ICT Literacy) como los intereses, actitudes y habilidades de los individuos para utilizar, de manera apropiada, las tecnologías digitales para acceder, gestionar, integrar y evaluar la información, construir nuevos conocimientos y comunicarse con otros, con la finalidad de participar efectivamente en la sociedad; la International Society for Technology in Education, ISTE/NETS (2006) propuso los Estándares sobre tecnología educativa, centrándose mas en las habilidades y conocimientos especializados que en los aspectos instrumentales, entre otras.

Jordi Vivancos dibuja su evolución como una escalinata de varios peldaños, en la van subiendo los estadios de las TIC en educación, y las visiones institucionales que se han tenido a lo largo de las últimas décadas.

Diferencia entre

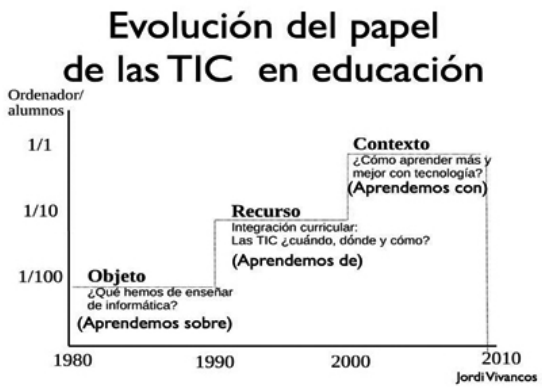
- Aprender sobre, que apoda alfabetización
- Aprender de, que apellida como recurso didáctico
- Aprender más y mejor con que lo encuadra en la competencia digital (CD)

Y a partir de ahí describe el recorrido de esta manera de entender la alfabetización como un camino que llega a impregnar el currículo de TICs, representada en este mapa conceptual de la Figura 3.

Jordi Vivancos cree que el tratamiento de la información y la competencia digital, TICD, engloba los planteamientos de las demás alfabetizaciones, es una especie de suma de todas ellas.

Y lo resume en un proceso como el que detalla el mapa conceptual que aparece a continuación (Figura 3):

- la relación suplementaria establece una separación entre las TIC y el currículo.
- El modelo complementario implica el uso en algunas áreas o actividades, con formación diferenciada: se alfabetiza sobre las TIC.
- La integración curricular supone una disponibilidad de la tecnología para usarla cuando lo requiera el proceso de enseñanza-aprendizaje.
- La impregnación del currículo es la plena madurez de la adopción tecnológica: las TIC se hacen invisibles, están a plena disposición del alumnado y profesorado, usándose como instrumento de trabajo intelectual, y construcción compartida y creativa del conocimiento.





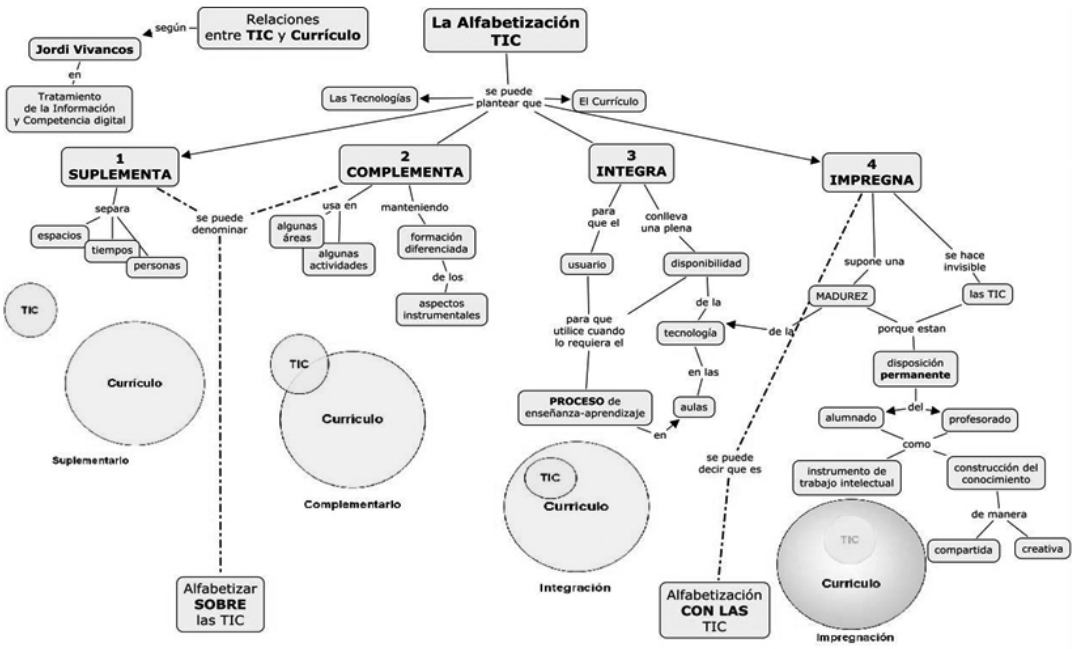


Figura 3. La evolución de la relación entre las TIC y el currículo educativo según Jordi Vivancos (2008)

3 La competencia digital

En el ámbito educativo, cuando el desarrollo de las competencias se convierte en el centro de la planificación y programación pedagógica, podemos afirmar que la alfabetización pasa por desarrollar la competencia digital, (CD) que Tíscar Lara (2009) enuncia así: "disponer de unas habilidades comunicativas, para ser una persona autónoma, eficaz, responsable, crítica y reflexiva". Vemos resumido este concepto en el mapa adjunto (Figura 4).

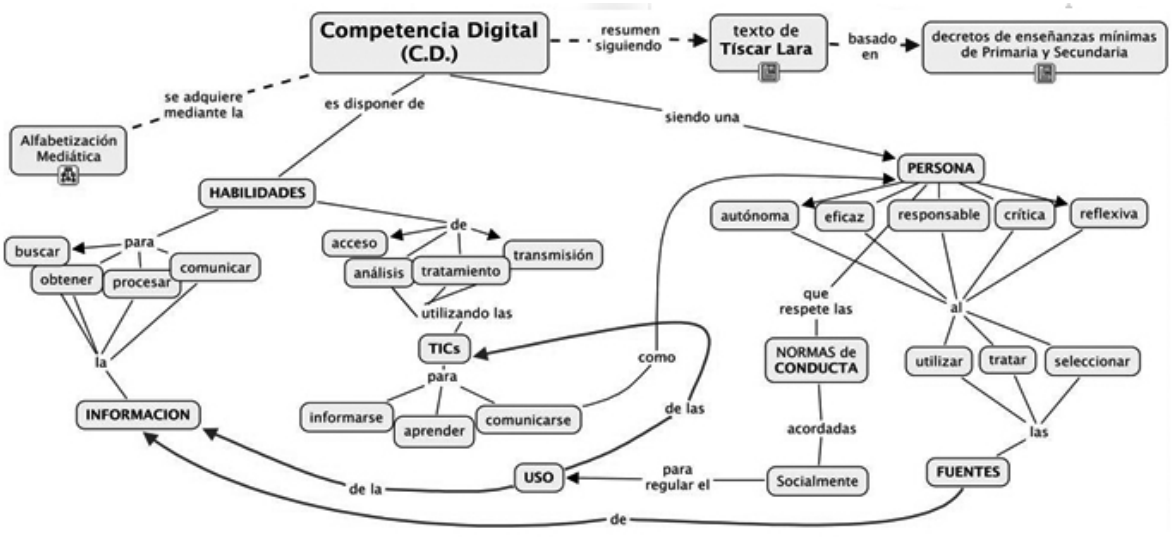


Figura 4. La adquisición de la competencia digital: habilidades que permiten ser autónoma, eficaz, responsable, crítica y reflexiva

Esta competencia, según el profesor Adell, es un conjunto de alfabetizaciones, que abarca por lo menos, estas 5 dimensiones:

- alfabetización informacional,
- alfabetización tecnológica,
- alfabetizaciones múltiples
- la competencia cognitiva y
- la ciudadanía digital

Para este profesor de la UJI, son los elementos básicos sobre los que se construye esta competencia, sobre los que pivotan las necesidades de la alfabetización actual.



4 La escuela: un contexto en que se desarrolla esta alfabetización

Intentando responder a la pregunta ¿donde estamos educando? hay que tener en cuenta que los educadores trabajamos en un panorama info-comunicativo, para el que las competencias que ha de adquirir el profesorado son las que desearía desarrollar en su alumnado. Es decir el tutor debe saber por lo menos, lo que plantea que sus aprendices deberán alcanzar al final de la etapa obligatoria (los objetivos de la ESO, que actualmente en España se alcanzan a los 16 años). Hay autores que hablan de infoxicación directamente.



Las características de este contexto están hoy en día muy influenciadas por un cambio profundo en la forma de entender la comunicación y de los medios que la vehiculizan: es decir en la forma que llegan los textos.

Si aceptamos que la presencia e influencia de Internet es un factor decisivo en la que Manuel Castells caracteriza como sociedad-red (ver el mapeado que realiza Manuel Aguilar en Mensaje Bioquímico), podemos afirmar que:

- todos los aspectos de la vida personal, grupal y social de las personas
- se desarrollan en un entorno comunicativo que,
- antes o después, mientras trabaja o descansa, cuando consume o cuando produce,
- se va a ver traducido a ceros y unos, que corren a la velocidad de la luz.

El profesor Adell sugería a la audiencia del JEDI (Deusto 2010) que "la escuela con las herramientas actualmente disponibles se puede abrir al mundo, y romper las barreras que lo separan diariamente de un contexto mas flexible y abierto que lo que los libros y la enseñanza tradicional representan. Y convertirse en un nodo, dejando de ser una isla." En este contexto abierto y líquido nos estamos moviendo actualmente. No es una época de cambio solamente:

es un cambio de época.

4.1 El cambio en el rol educador-educando

Esta revolución comunicativa, de emisores múltiples a receptores simultáneos, de emirecs, obliga a replantear el papel y la manera de funcionar de las personas implicadas en los procesos educativos y comunicativos: ahora su rol se corresponde con el de produsuarias, porque según la Figura 5, al mismo tiempo pueden:

- producir información e interacción en la red y
- usar la que otras productoras-usuarias han compartido en los entornos digitales

Mientras quien produce escribe en un blog, habla en un podcast, publica en un portal, agrega en una feed, pega una imagen o comenta en un foro, licencia creativamente, está construyendo la red quien usa servicios en la red lee los post, escucha un vídeo o audio, ve y oye elementos multimedia, sigue rss, corta y copia textos, critica y opina, respeta la autoría, está re-construyendo también la red.

Así quien se esta educando es a la vez un poquito, educador de sus iguales, porque la sociedad-red del conocimiento la estamos construyendo on-line entre todos y todas; y quien tiene la responsabilidad de educar a sus hijos, o alumnos necesita también, ser educado y sentirse aprendiz, en un nuevo entorno, que ni siquiera existía cuando se formó como profesional (como es el caso del autor del artículo). Tíscar Lara (2009) dibuja en la Figura 6 un certero esquema de las nuevas relaciones a establecer entre estudiantes-aprendices y profesorado (también perpetuo aprendiente), en una época en la que la actitud Web2.0 más características es la perpetua beta: "el modelo del profesor pasa de ser una fuente o un filtro de conocimiento a ser un facilitador del aprendizaje, un tutor del proceso."

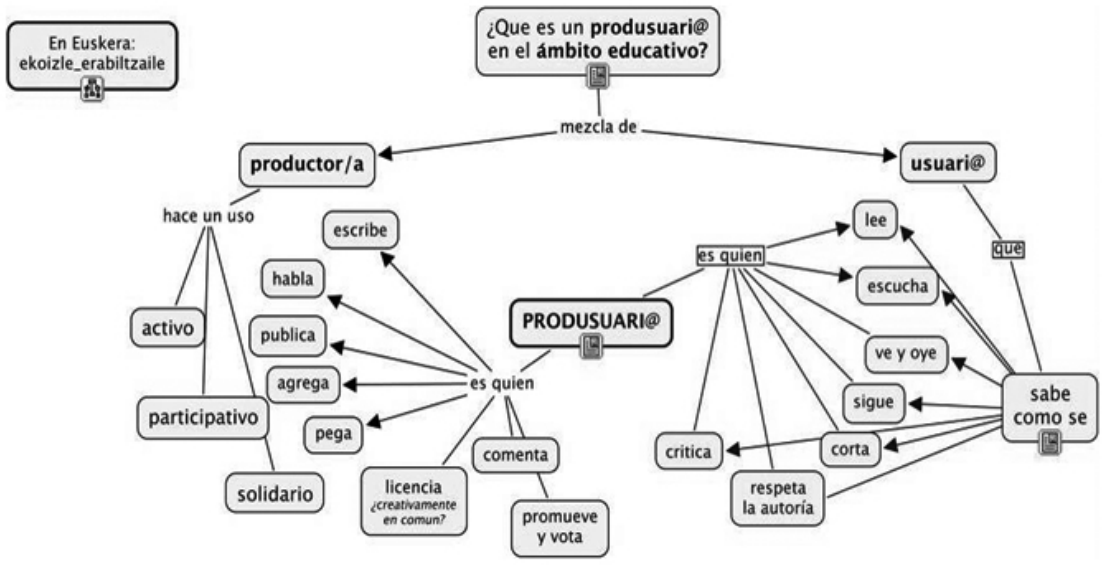


Figura 5. Nuevos roles desarrollados de modo simultaneo por quienes usan los servicios de la nueva Internet (Web 2.0)

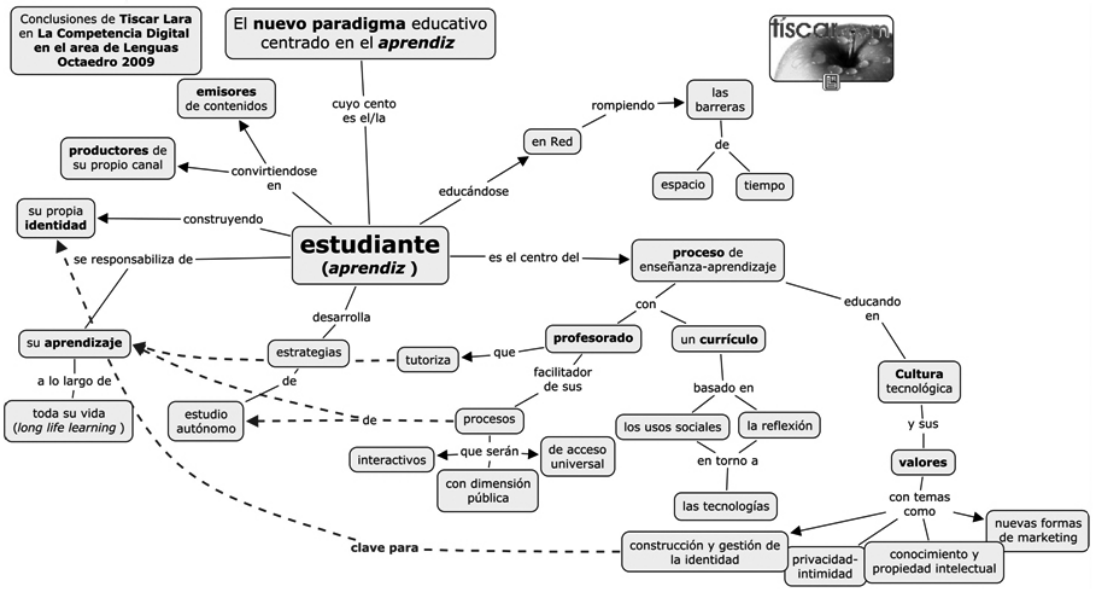


Figura 6. Conclusiones del capítulo Alfabetizar en la cultura digital de Tíscar Lara tituladas Aprende Haciendo (pag. 35)

4.2 La escuela como marco de la alfabetización

La escuela, entendida como un lugar en el que acuden estudiantes y profesionales de la educación en las etapas obligatorias, es un espacio en el que la interacción entre los iguales y con las personas adultas, posibilita la adquisición de conocimientos y el desarrollo de la competencia digital. En la Figura 7 Lara resume la concepción de la alfabetización mediática, coincidentes con las las finalidades educativas: el desarrollo de la capacidad para acceder, analizar y evaluar el poder de las imágenes, sonidos y mensajes, con el objetivo de incrementar la conciencia sobre las formas de los mensajes mediáticos que se encuentran en la vida cotidiana los jóvenes inmersos en la cultura contemporánea. ¡Casi nada!

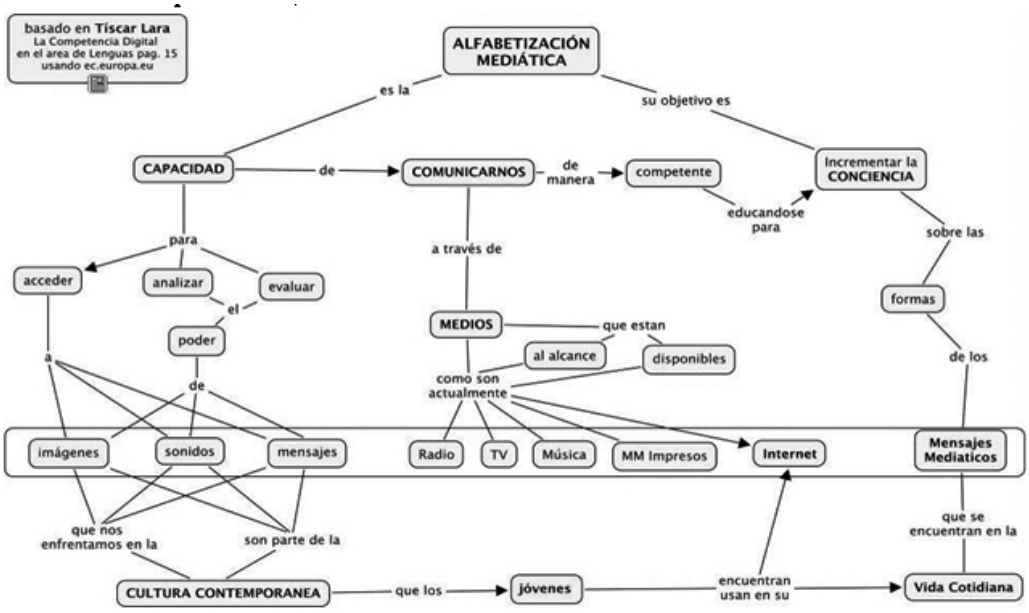


Figura 7. Tíscar Lara (2009) en La competencia digital en el área de lenguaje pag. 15

Esta alfabetización supone 3 tipos de saberes, que enuncia Tíscar Lara en la obra citada (Figura 8):

- los lenguajes y las técnicas, que conforman la dimensión lingüística
- la capacidad de interpretación crítica y productiva, el saber hacer y
- la participación ciudadana, que es el saber ser o dimensión cívica

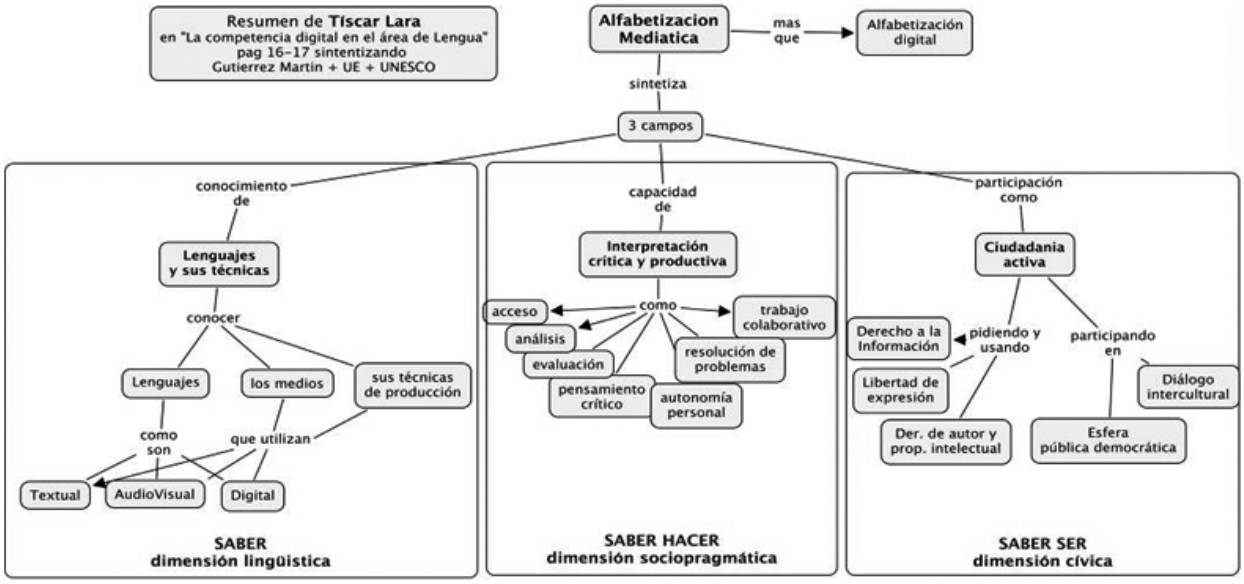


Figura 8. Resumen de Tíscar Lara sobre la Alfabetización mediática de diversas fuentes

Lara coincide con los informes y grupos de trabajo de la UNESCO, que concretan los 3 aprendizajes claves: el aprender a aprender, el aprender a hacer y el aprender a ser.

Manuel Area Moreira (2008) hace una propuesta integradora denominada multialfabetización, recogiendo (Figura 9) las 4 dimensiones claves de un aprendizaje múltiple, global e integrado. Fija estas 4 dimensiones:

- la instrumental: el dominio técnico, el saber manejar hardware y sotfware, como herramientas o útiles
- la cognitiva: adquirir conocimientos y habilidades específicos para hacer un uso inteligente
- la actitudinal: desarrollando actitudes y normas con actitud personal y social positiva, ni tecnofóbico, ni acrítico y sumiso, sino ser colaborativo, respetuoso y empático con las demás personas
- la axiológica: tomando conciencia de que las TIC no son asépticas ni neutrales, teniendo valores y criterios éticos para su uso, evitando conductas de comunicación socialmente negativas.

5 Un itinerario formativo: el mapa de ruta de la alfabetización

Ante tanta complejidad, lo mejor va a ser ir a lo fundamental, a lo básico: alfabetiza a tu alumnado, en lo que te gustaría estar tu mismo alfabetizado. Para lo cual hace falta saber leer y saber escribir (en analógico y en digital) y comunicarse, por los medios disponibles: hablar, debatir, y si se quiere, también publicar en Internet.

Tíscar Lara con una visión ecológica del sistema comunicativo (Figura 10a y Figura 10b), da unos avisos a navegantes, para no perderse en el mar por el que pretendemos navegar: un mundo con Internet. Con un enfoque comunicativo de la cultura de participación en la red nos anima a re-utilizar, re-interpretar, devolver y compartir nuestro conocimiento en la red. Es decir, utilizar lo que leemos, escribir lo que interpretamos y comunicarlo en público.

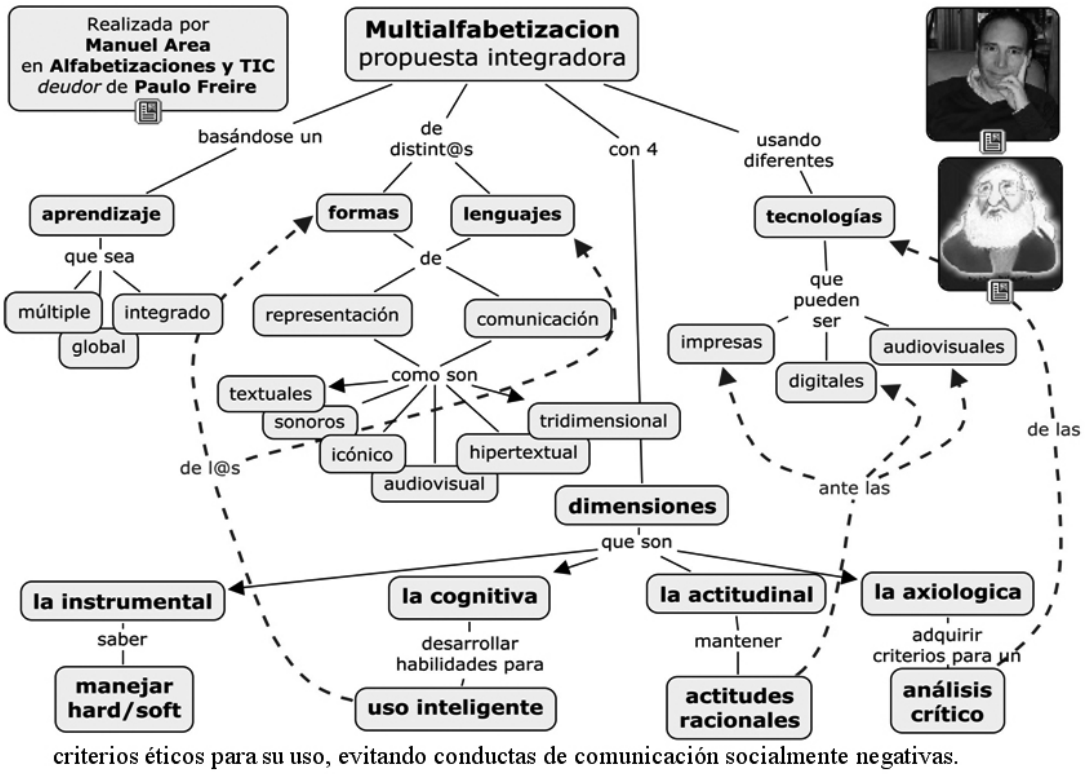


Figura 10a. Forma piramidal de ver el proceso de alfabetización según Perez Tornero

La propuesta de Francisco Muñoz Peña dibuja un sencillo itinerario formativo para el profesorado, siguiendo a David Warlick: el que podría recorrer el alumnado para su alfabetización digital. Sugiere que puede: comenzar creando y escribiendo en su propio blog, unirse a redes sociales, experimentar en clase, y compartir los resultados, invitando a otros profesores a unirse a la conversación en la red. Sencillo y efectivo recorrido.

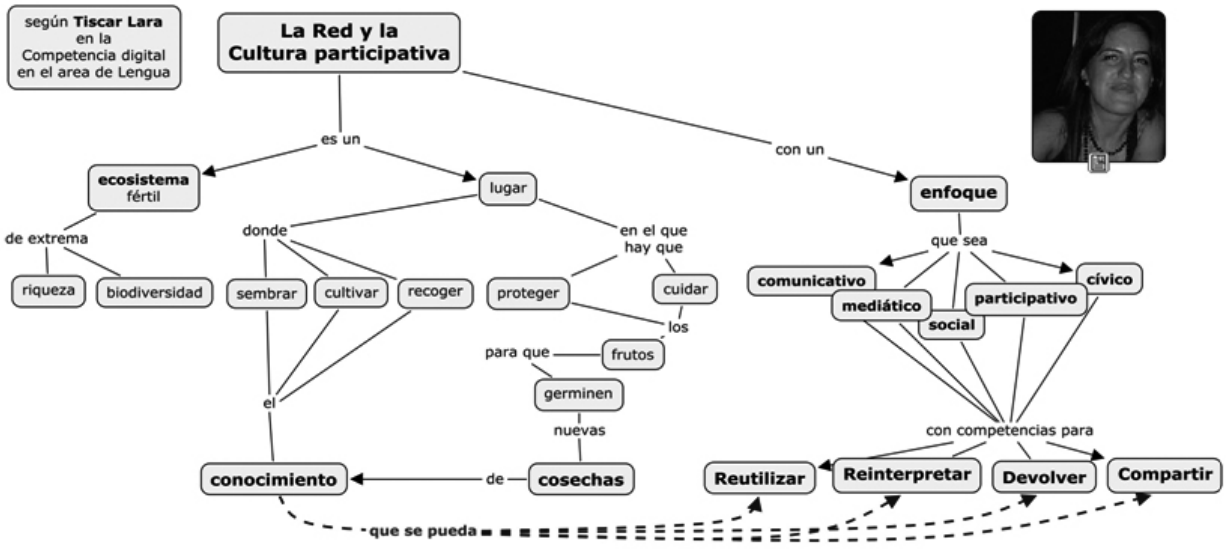


Figura 10b. Forma piramidal de ver el proceso de alfabetización según Perez Tornero

6 La aportación de los MC a la alfabetización actual

A. Cañas y J. Novak plantean que los MC "son herramientas gráficas para organizar y representar el conocimiento, incluyendo concepto y relaciones, representados de forma jerárquica, respondiendo a alguna pregunta de enfoque que ayude a contextualizarlo". Los MC son una buena manera de escribir y publicar en el nuevo contexto info-comunicativo lo que vayamos buscando, leyendo, analizando, resumiendo, aprehendiendo.

Si leer, escribir y publicar, son tres claves del proceso comunicativo actual, tras leer en papel o en soportes virtuales, escribir en documentos textuales y gráficos con la ayuda de un organizador gráfico como CmapTools, que representa lo que sé y el aprendizaje que estoy construyendo, y posibilita diferentes modalidades para exportarlo, y posteriormente publicarlo... es una herramienta eficaz para personas alfabetas.

Mi experiencia personal es que los mapas están siendo una herramienta clave, que me ayudan a sintetizar, relacionar y expresar lo que se yo (y lo que sabemos entre tod@s); enlace a enlace, concepto a concepto, sigo construyendo y compartiendo conocimiento. Por eso os animo a que insertéis y embebáis CMs, en blogs, en páginas web, en documentos... leyendo, escribiendo y publicando para construir una red con menos analfabetos.

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Viña del Mar, Chile, 2010

MAPAS CONCEPTUALES EMPLEADOS EN INGENIERÍA: KBFD (KNOWLEDGE BASED FATIGUE DESIGN)

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Resumen. En el presente artículo se describe la primera herramienta conocida de ayuda al Ingeniero en el proceso de diseño de componentes respecto a su resistencia a la Fatiga mecánica. Esta herramienta está basada en Mapas Conceptuales. Ha sido desarrollada y probada en tareas de consultoría y de formación tanto en Europa como en Estados Unidos.

1 Diseño a Fatiga basado en el Conocimiento

1.1 Introducción

El presente documento representa la primera publicación del proyecto de investigación que se realizó para la obtención del título de Suficiencia de Investigación dentro del Programa de doctorado "Ingeniería Mecánica Aplicada y Computacional" impartido por el Departamento de Ingeniería Mecánica, Energética y de Materiales de la Universidad Pública de Navarra (España). Este trabajo se realizó bajo la supervisión de los doctores Javier Ros e Isidro Zabalza, pertenecientes a dicho departamento, y con la colaboración del catedrático de Didáctica de las Ciencias Experimentales Fermín González. El Trabajo fue presentado en Pamplona en julio de 2008.

1.2 Objetivo

El objeto del proyecto de investigación es la creación de una herramienta que ayude al Ingeniero mecánico en el proceso de diseño de componentes respecto a su resistencia a la Fatiga mecánica (en adelante denominada simplemente como "Fatiga"). Esta herramienta se ha denominado con acrónimo en inglés KBFD (Knowledge Based Fatigue Design), subrayando la filosofía en la que se fundamenta: diseño basado en el conocimiento.

KBFD pretende ser una potente herramienta de diseño, fácil de utilizar y flexible en todos los niveles tanto teóricos como prácticos en los que se puede emplear: investigación, ingeniería profesional y docencia de la ingeniería.

1.3 El "problema" del Diseño a Fatiga

1.3.1 Definición de Fatiga

La Fatiga mecánica ha sido y es una de las principales causas de fallo en sistemas de todo tipo - mecánicos, eléctricos y electrónicos, entre otros - siendo muy crítica en sectores como el de los medios de transporte y la energía.

Es un fenómeno que aparece sin previo aviso y está condicionado por el uso que de cada uno de los componentes que forma el sistema de estudio se haya realizado en toda su vida útil, incluyendo su propio proceso de fabricación. Es en consecuencia un fenómeno muy difícil de predecir y altamente pluridisciplinar.

Se caracteriza por ser un fenómeno localizado al producirse en zonas puntuales del componente, progresivo porque ocurre a lo largo de un periodo de tiempo a pesar de que pueda parecer un fenómeno repentino y permanente por ser irreversible.

1.3.2 Problemática de la Fatiga en la actualidad

El problema del diseño a Fatiga ha sido estudiado desde mediados del siglo XIX y ha sido fundamental en sectores como el ferroviario y el aeronáutico, implicando la inversión de grandes recursos económicos, así como la pérdida de numerosas vidas humanas.

Sin entrar en detalles sobre el problema mismo del diseño a Fatiga, mencionar que este campo de la ingeniería mecánica es en sí mismo es muy complejo. Como muestra se enunciarán las siguientes paradojas de los métodos de diseño a fatiga actualmente empleados.

Paradoja 1
El carácter localizado del proceso, hace que deban tenerse en consideración aspectos hasta una escala atómica del material. En contraposición, el análisis del proceso se realizada tradicionalmente mediante métodos basados en resultados experimentales a nivel macroscópico, caracterizados mediante funciones de variables estadísticas.

Paradoja 2
El diseño de componentes se basa habitualmente en los resultados experimentales provenientes de muestras del material que buscan obtener una gran repetibilidad y cuyas características en la mayoría de los casos difieren de las características del material real del componente en estudio, hasta el punto que presentan comportamientos en vida a Fatiga diferentes en varios órdenes de magnitud.

Por otra parte, a pesar de los desarrollos realizados en los ámbitos tanto académicos como de investigación, la industria presenta una gran resistencia a la incorporación en sus procesos de diseño y análisis los nuevos avances que se hayan realizado.

El presente trabajo trata de crear puentes que unan estos ámbitos así como conciliar las paradojas anteriormente descritas, al crear una herramienta de comunicación clara y transparente entre el conocimiento de los individuos, esto es, el mapa conceptual.

2 Desarrollo de la Investigación

2.1 Origen de la idea

El germen de la idea en la que se basa el proyecto KBFD se encuentra tanto en mi experiencia educativa como profesional.

Ya en la enseñanza secundaria experimenté el aprendizaje significativo así como los mapas conceptuales [González ,2008], [Novak, 1984] y [Novak, 2006] de la mano de mi profesora de biología. A falta de una herramienta como Cmap Tool [Cañas, 2004], empleábamos papel y pizarra, e incluso en algunos casos el conjunto de la clase llegábamos a consensuar los mapas.

Durante mis estudios de Ingeniería Industrial, en una pequeña parte de una única asignatura, me inicié en el campo de conocimiento de la Fatiga Mecánica. Este campo me impresionó especialmente debido en parte al entusiasmo del profesor, así como a mi predilección por la Ciencia de los Materiales. Estaba muy claro que era un tema muy interesante, mezcla de varias disciplinas científicas y con una importantísima aplicación práctica.

Más adelante, trabajando en el departamento de Fatiga de un centro de investigación del automóvil, entré en contacto con el mundo de los ensayos de vida a fatiga, así como los modelos matemáticos que se empleaban para la estimación de la misma. Al mismo tiempo realicé los cursos de doctorado, incluyendo asignaturas relacionadas con la Fatiga, la Mecánica de la Fractura y los ensayos.

Fue en este periodo cuando me di cuenta de la incomunicación existente entre los mundos docente e investigador con el mundo práctico de las empresas y los centros tecnológicos, y de las oportunidades que podría surgir de una mejora en la relación de los mismos.

Posteriormente trabajé como consultor de Fatiga de una empresa americana con base en Alemania, en empresas ubicadas tanto en Alemania como España. Durante este periodo de dos años fue cuando desarrollé el trabajo en el que se basa la presente publicación.

2.2 Desarrollo de la investigación

El trabajo de investigación fue realizado paralelamente con la aplicación práctica del mismo en mi actividad profesional.

El estudio personal fue siendo plasmado en mapas conceptuales para posteriormente ser aplicado en tareas de resolución de problemas y formación a clientes. Por un lado, el mapa conceptual permite plasmar el conocimiento a través de conceptos y sus relaciones entre ellos, y por otra, de su interacción con el diseñador surgirá la solución a la problemática que se quiera resolver.

Adicionalmente los resultados obtenidos así como el mapa en sí mismo fueron discutidos con compañeros de trabajo y clientes, en Europa y en Estados Unidos.

La valoración y la crítica del trabajo fueron de gran ayuda para la toma de decisiones en relación al diseño de los mapas conceptuales, así como para la resolución de las discusiones relativas al conocimiento propiamente dicho que tuvieron lugar.

2.2.1 Uso de Mapas Conceptuales en el área de la Fatiga Mecánica

El uso de los Mapas Conceptuales, durante la realización del proyecto, como ayuda en la resolución de problemas relacionados con la Fatiga mecánica en la automoción produjo las siguientes experiencias en las personas que tuvieron la posibilidad de usarlos.

Los Mapas conceptuales permitieron representar de manera explícita conocimiento, de forma que este conocimiento pudiera ser compartido y posteriormente consensuado de forma sencilla e intuitiva.

Además, los Mapas Conceptuales permitieron realizar con gran facilidad conexiones a otras áreas científicas y tecnológicas, necesarias para clarificar la naturaleza multidisciplinar de la Fatiga.

Una vez realizados los Mapas Conceptuales, estos podían ser utilizados de muy variadas maneras, como formación tradicional, autoformación, pudiendo llegar incluso a crearse de forma muy sencilla procedimientos, check-lists, …

La herramienta KBFD supone, hasta donde los autores conocen, la primera ocasión en que se realiza un sistema de ayuda en el diseño a Fatiga basado en Mapas Conceptuales, así como la trascripción de un libro a un Mapa Conceptual, con la extensión y nivel de detalle que se presenta en este trabajo.

Durante el periodo de tiempo que duró el trabajo se puso en contacto a una universidad española con la empresa americana para la inclusión de sus resultados científicos en su portfolio de productos. La presentación de los desarrollos fue realizada empleando Mapas Conceptuales. En este proceso se pudo comprobar como la relación del mundo Industrial con el mundo académico / investigador puede ser mejorada mediante el uso de esta herramienta, al facilitar el entendimiento entre los mismos.

3 KBFD – Diseño a Fatiga Mecánica basado en el Conocimiento

3.1 Estado del arte

A continuación se describirán algunas metodologías de diseño empleada en ingeniería, así como la aportación de KBFD sobre las mismas.

3.1.1 Procedimiento de diseño vs. Diseño basado en el conocimiento

Los procesos de diseño tradicionales suelen estar basado en procedimientos, los cuales se caracterizan por la realización de tareas repetitivas de forma eficaz y con recursos humanos mínimos. Sin embargo, diseñar en base a procedimientos, presenta como desventajas, por ejemplo, la representación del conocimiento de una forma estática y parcial, necesitando la tipificación de los problemas y limitando además la creatividad en el proceso de diseño.

Como ejemplo, relacionado además con la temática del presente trabajo, se puede citar el proyecto realizado a nivel europeo (Proyecto FITNET) [Gutiérrez-Solana, 2007] que ha dado como resultado un gran procedimiento unificado a nivel europeo, con la pretensión de proveer al diseñador de una herramienta para el diseño a Fatiga.

El KBFD está basado en los mismos conocimientos que el FITNET y persigue sus mismos objetivos, pero permite abarcar una problemática mucho más amplia. La representación de conocimiento complejo de una forma mucho más eficaz mediante los Mapas Conceptuales y la no necesidad de tipificar los problemas a resolver (limitación propia de los procedimientos de diseño) confiere una gran superioridad al KBFD frente a cualquier procedimiento de diseño.

3.1.2 La automatización del Diseño

En cualquier proceso toda tarea repetitiva es susceptible de ser automatizada, y como tal, el proceso de diseño puede representar en algunos casos tales tareas repetitivas [Prijic, 2005)].

Algunas tecnologías como los Sistemas Expertos o las Redes Neuronales, que forman parte de una rama de la ingeniería denominada Inteligencia Artificial, permiten automatizar procesos avanzados de diseño, tratando de emular el comportamiento humano. Por limitaciones de espacio, las tecnologías mencionadas no serán descritas.

Sin embargo, sí que se cree conveniente la mención de los sistemas expertos a modo de comparación para permitir valorar las ventajas que los mapas conceptuales presentan respecto a otro sistema de diseño basado en el conocimiento. Concretamente, esta comparación es especialmente enriquecedora debido a la gran similitud que existe entre el proceso de elaboración y la finalidad que se da tanto en los mapas conceptuales como en los sistemas expertos.

3.1.2.1 Los Sistemas Expertos

Un Sistema Experto se define como un sistema informático (hardware y software) que pretende simular a un conjunto los expertos humanos en un área de especialización dada [Castillo, 1997]. Por lo tanto, los sistemas expertos, más allá de ser meros procedimientos de diseño, tratan de emular la inteligencia humana potenciándola por un lado mediante la inclusión del conocimiento de varios expertos y por otro mediante una reducción del tiempo de respuesta que permite la implementación de la herramienta a través de software.

Los sistemas expertos incluyen necesariamente un interfaz de comunicación predefinido con el usuario, tanto para “entrenar” o “enseñar” al sistema experto, como para obtener finalmente información del mismo. Este interfaz requiere una estandarización que provoca una limitación similar a la que comentaba anteriormente en relación con los procedimientos.

Su sistema de “razonamiento” está basado en la información de aprendizaje y en el uso de funciones lógicas y estadísticas.

El presente proyecto no pretende emular a un hipotético sistema experto para diseño a Fatiga: ningún procedimiento será implementado automáticamente por software, sino que cualquier problema será resuelto mediante la interacción entre uno o varios expertos y el Mapas Conceptuales de la Fatiga.

A continuación se realiza una comparación de los Mapas Conceptuales respecto a los Sistemas Expertos, remarcando las ventajas de los primeros:

- Los Mapas Conceptuales potencian la inteligencia humana durante la interacción explícita entre el mapa y los usuarios, tanto en fases de aprendizaje como de resolución de problemas, frente a los sistemas expertos que únicamente la potencian en la fase de aprendizaje.
- Los Mapas Conceptuales no ponen límites ni formas a la interacción con los usuarios, presentando una

interface de uso extremadamente más flexible que los Sistemas Expertos.

- La interacción con el usuario con los Mapas Conceptuales se puede basar en consultas o problemas a resolver, pero no es necesario definir previamente cuáles son dichas consultas ni tampoco el proceso que debe realizar tras la pertinente consulta.
- En los Mapas Conceptuales no existen procesos relacionados con consultas y consecuencia la naturaleza de la consulta es a priori ilimitada. La realización de una consulta al mapa requiere un trabajo que depende de la calidad del mapa (base de datos de conocimiento), la dificultad del problema y la habilidad de las perso nas implicadas.
- La única necesidad de mejoras futuras consiste en incorporar nuevo conocimiento y mejorar la "definición" del conocimiento existente. Este problema es el mismo en los dos sistemas.

3.2 Mapa Conceptual de la Fatiga

El KBFD está basado en la interacción entre expertos de diferentes niveles en el campo de la Fatiga y el Mapa Conceptual de este campo de la Ingeniería realizado a lo largo del presente trabajo.

Debido a las limitaciones del presente artículo, únicamente se van a desarrollar aquí aspectos relacionados con el mapa conceptual que sobre la Fatiga realizado.

Este mapa se ha basado principalmente en un libro básico de Fatiga [Stephens 2001], escogido por tratar todos los aspectos fundamentales del diseño a Fatiga, desde un punto de vista tanto teórico–científico como práctico–ingenieril.

Además se ha incorporado conocimiento proveniente de mi propia experiencia profesional.

3.2.1 Estructura básica del Mapa Conceptual

En la Figura 1 se muestra el Mapa Conceptual inicial que sirve como ayuda en el diseño a Fatiga.

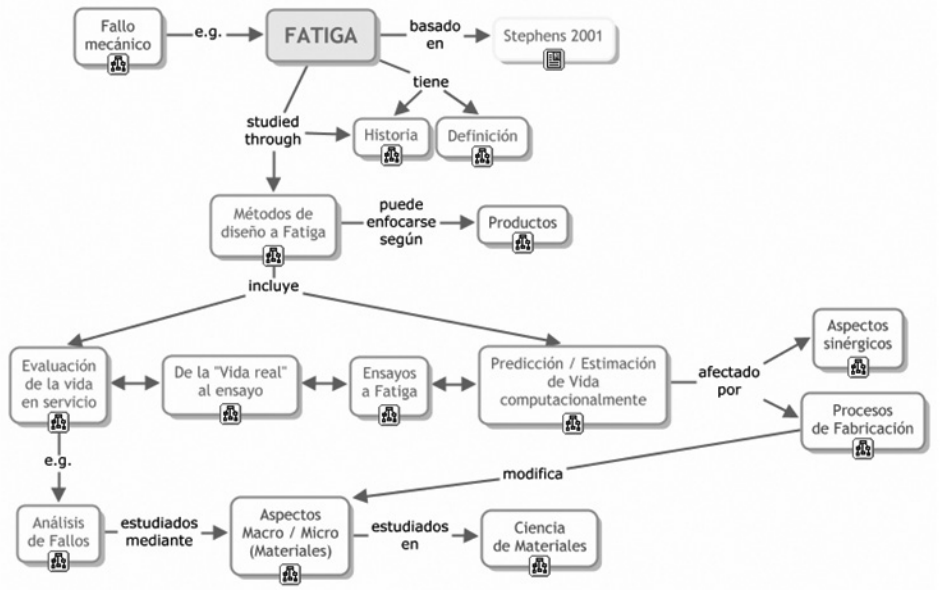


Figura 1. Mapa Conceptual inicial para emplear como ayuda en el diseño a Fatiga

Debido a la cantidad de mapas generados durante este trabajo, solo algunos de ellos aparecerán mencionados en este documento para ilustrar los comentarios que se vayan realizando.

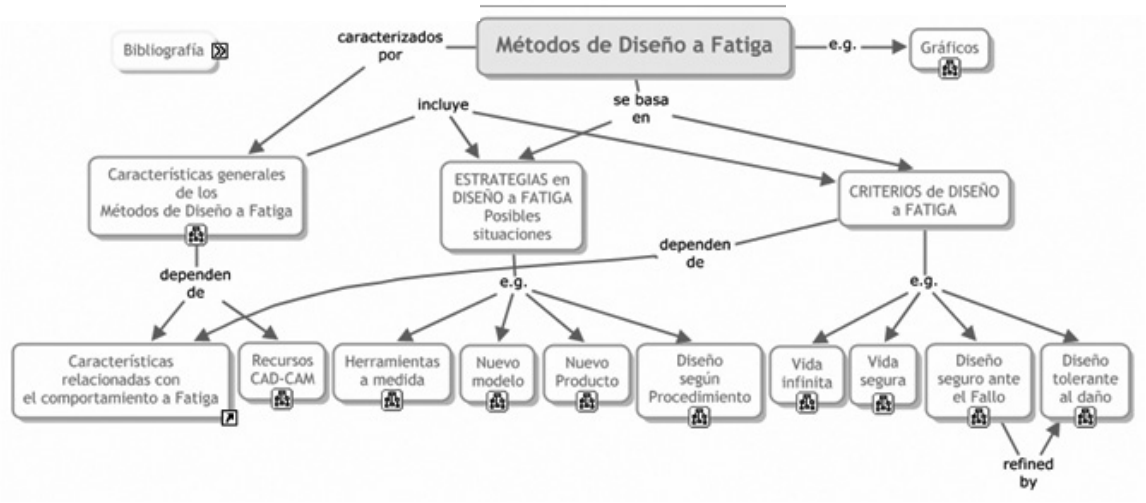


Figura 2. Métodos de diseño a Fatiga

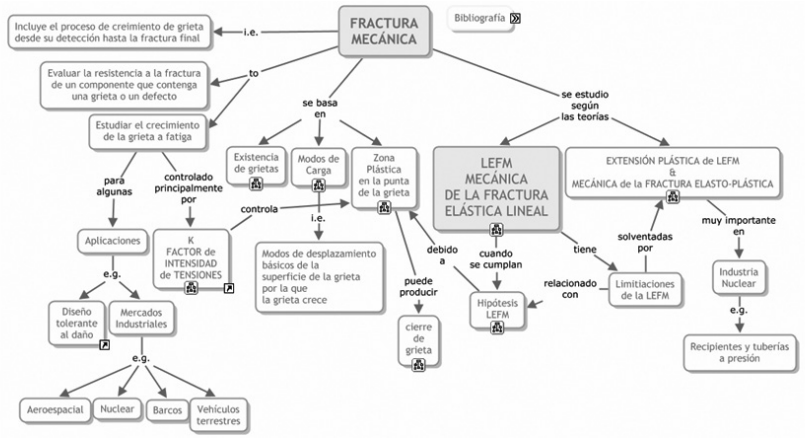


Figura 3. Mecánica de la Fractura

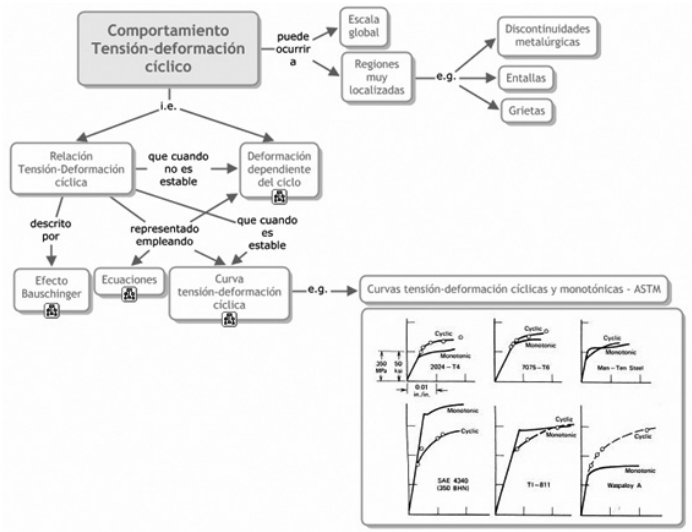


Figura 4. Comportamiento cíclico Tensión - Deformación

A continuación indican las conclusiones más destacadas de la elaboración del mapa.

3.2.2 Problemas aparecidos durante la elaboración de los Mapas Conceptuales

En la elaboración de los mapas han ido apareciendo diferentes problemas, algunos de los cuales serán a continuación únicamente enumerados, debido a la extensión del presente artículo.

Estructura de los Mapas

- No solución única en la distribución de los conceptos.

Debido a la enorme variabilidad en la distribución de los conceptos, se ha adoptado en la mayor parte de los casos una distribución que "guía" al lector en la lectura del mapa, adoptando por tanto una distribución horizontal lineal.

Por otro lado, en ningún caso se ha sacrificado la inclusión de conceptos adicionales que no cumplan esta condición si ha sido necesario.

- Número muy extenso en las relaciones conceptuales.

Durante el desarrollo del mapa conceptual, éste se ha ido enriqueciendo de un gran número de relaciones entre los distintos conceptos, hasta el punto de en numerosas ocasiones hacer difícil su comprensión. En estos casos se han agrupado los conceptos por temáticas, de forma que se han podido generar distintos mapas conceptuales según estas temáticas de lectura más sencilla.

Relaciones entre conceptos: tipos y jerarquía

- Conceptos más generales por debajo de conceptos menos generales.

No siempre ha podido mantener una relación jerárquica – geométrica: el uso de una gran variedad de conceptos con sus relaciones cruzadas, y la distribución espacial únicamente bidimensional ha impedido mantener este criterio. En cualquier caso, se han priorizado en cada mapa ciertas temáticas en las que una distribución jerárquica – vertical ha podido llevarse a cabo.

- Las relaciones de inclusividad no siempre son del mismo tipo.

Se han detectado distintos tipos de relaciones de inclusividad, como las subcategorías, los ejemplos, ect. Considero un tema de gran interés la tipificación de los distintos tipos de inclusividad y su caracterización diferenciada en los mapas conceptuales. Este tema podría ser de interés para futuros desarrollos.

3.2.3 El uso de los mapas como herramienta pedagógica

A lo largo del proceso de elaboración del mapa conceptual, los mapas se revelaron como una muy buena herramienta didáctica para transmitir conocimientos. A continuación se muestran algunos ejemplos de los mismos.

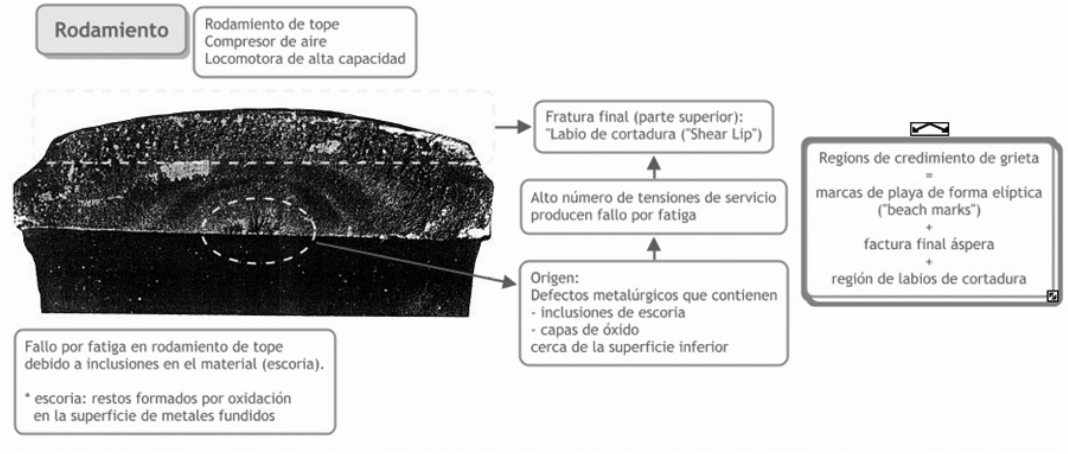


Figura 5. Ejemplo de Mapa Conceptual para aclaración de imágenes

Aclaración de Imágenes

En el desarrollo de esta aplicación, los mapas conceptuales se han manifestado como una herramienta idónea para explicar a aclarar imágenes, a modo de organizadores gráficos.

Como puede apreciarse en el ejemplo, es posible relacionar conceptos con gráficos e imágenes. Esta aplicación es de gran interés a nivel docente así como para la elaboración de material de auto aprendizaje o aprendizaje a distancia.

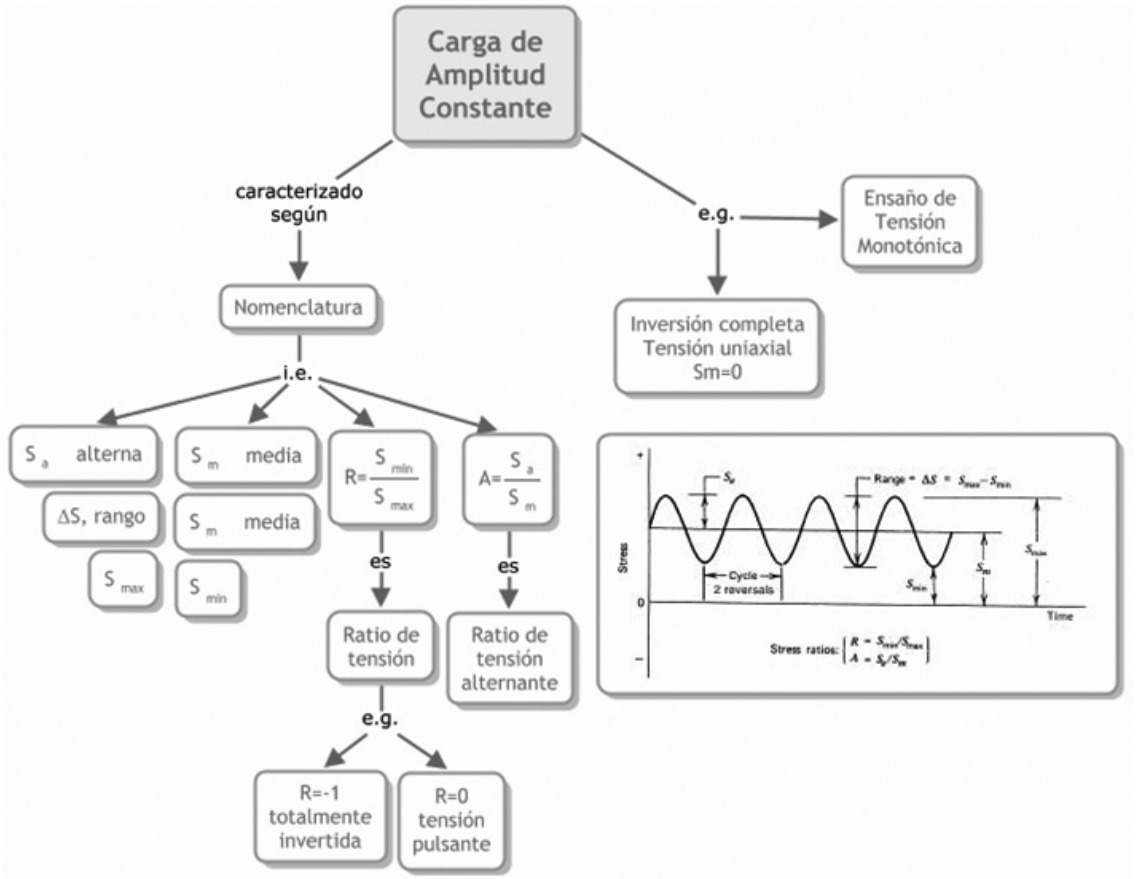


Figura 6. Ejemplo de aclaración de gráfico y ecuaciones asociadas

Aclaración de ecuaciones matemáticas

Los mapas se muestran como una herramienta muy útil para aclarar y explicar relaciones matemáticas complejas.

4 Conclusiones

4.1 Conclusiones generales

- Los Mapas conceptuales permiten representar de manera explícita el conocimiento necesario para poder realizar tanto diseño como investigación en el campo de la Fatiga mecánica.
- Este conocimiento puede ser compartido de forma sencilla e intuitiva, al estar basado en conceptos y representarse mediante una herramienta gráfica.
- Debido al carácter multidisciplinar de la Fatiga, es necesario recurrir a otras áreas científicas y tecnológicas para su estudio. Los Mapas Conceptuales permiten realizar esta conexión con gran facilidad.
- El conocimiento plasmado en Mapas Conceptuales puede utilizarse en múltiples aplicaciones tanto de investigación, como prácticas, pudiendo llegar incluso a crearse de forma muy sencilla procedimientos, check-lists, …

4.2 Aportaciones del presente proyecto

- KBFD: Por primera vez se realiza un sistema de ayuda en el diseño a Fatiga basado en Mapas Conceptuales.
- Los mapas conceptuales proporcionan un lugar de encuentro a la pluridisciplinaridad de la Fatiga mecánica.
- La trascripción de un libro a un Mapa Conceptual, con la extensión y nivel de detalle que se presenta en este trabajo, es un hecho sin precedentes.
- Relación del mundo Industrial con el mundo académico / investigador puede ser mejorada mediante el uso de esta herramienta.
- Esta herramienta permite la realización de auto aprendizaje así como de aprendizaje a distancia.

4.3 Futuras Aplicaciones

A continuación se enumeran posibilidades de desarrollo de la herramienta KBFD desarrollada en el presente proyecto.

APLICACIONES EMPRESARIALES

Servicios
- Dirección de Proyectos.
- Gestión de Reuniones.
- Gestión de la documentación de un proyecto.
- Gestión del conocimiento del proyecto.

Diseño
- Diseño a Fatiga.
- Diseño de ensayos.

Empresa de Servicios / Ingeniería
- Búsqueda de información sobre tema de interés.
- Selección de método de estimación de vida óptimo para problemas concretos de diseño.
- Desarrollo de formación especializada a medida.

SECTORES DE INTERÉS

Industria de Automoción
- Ensayos a Fatiga de sistemas mecatrónicos.
- Repetibilidad y precisión en los ensayos.
- Nuevos materiales: Composites.
- Fatiga térmica.

Industria de Generación eólica
- Estudio de cargas de trabajo.
- Materiales Compuestos.

Industria Aeronáutica
- Ensayos de predicción de vida.
- Materiales: materiales compuestos.
- Procesos de fabricación: soldadura.

5 Resumen

El presente artículo se describe para de un proyecto que desarrolla una herramienta que ayude al Ingeniero en el proceso de diseño de componentes respecto a su resistencia a la Fatiga mecánica. Esta herramienta está basada en un gran número de mapas conceptuales. Tanto el método desarrollado como el empleo de los mapas conceptuales en este campo son una novedad a nivel mundial.

6 Menciones

Este proyecto de investigación se realizó para la obtención de la Suficiencia de Investigación del Programa de doctorado “Ingeniería Mecánica Aplicada y Computacional” impartido por el Departamento de Ingeniería Mecánica, Energética y de Materiales de la Universidad Pública de Navarra, bajo la supervisión de Javier Ros e Isidro Zabalza y con la colaboración de Fermín González. El Trabajo fue presentado en Pamplona, en julio de 2008.

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Viña del Mar, Chile, 2010

MAPPING SOME DESIGN CONSIDERATIONS FOR LEARNING FROM TEXTS

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Abstract. Text study involves following a sequence of steps that assist in managing the complex process, applying various cognitive and metacognitive strategies, and constructing intermediate external representations. A procedure is proposed for constructing a sequence of external representations, based on a text to be studied, to aid the comprehension processes. These representations include a marked phrase list selected from the source text, a question list, descriptive and organizing concept maps, sentence and text summaries, and a model map reflecting a desired end for the comprehension process. Design considerations for producing technological tools for these tasks are discussed.

1 Introduction

Our concern is the process of learning from texts and how this process can be aided by using tools, such as Graphic Organizers (GOs), including concept maps. First, we briefly review and categorize the abundance of methods, techniques, or strategies (our preferred term) for comprehending texts that were introduced and applied at all grade levels with students of all ranks, including underachievers, developing students, and students with learning disabilities (e.g., Block and Pressley, 2002). Then, we will describe and demonstrate the use of these tools in the application of one reading comprehension strategy. Finally, we shall list several considerations of designing comprehension tools.

The term Strategy refers to a plan of action designed to achieve a particular goal, in our case the goal is learning and understanding a particular text or texts, so that we can answer questions about them or apply our understanding in new contexts, such as in writing an essay or in other tasks that utilizes our new knowledge. We broadly categorize this multitude into three complementing approaches: (1) managing and sequencing the reading process, (2) applying a single or a compendium of cognitive and metacognitive strategies, and (3) constructing external representations during the learning process.

One approach is to manage the process of reading and studying in general, a "do this and then do that" strategy. Some of us are familiar with the SQ4R reading strategy, an acronym which stands for: Survey in order to get the general idea of the content, structure, organization, and plan of the text; Develop Questions that provide a purpose for reading (this also activates prior knowledge); Read each section of the text to answer questions that were developed in the previous step; Recite - write summary answers to questions that were previously developed; Review outlines and previously generated notes and summaries to be able to retell what was read; And Reflect by linking together the information from the entire text and critically thinking about it (Richardson & Morgan, 1997). SQ4R was emanated from SQ3R (omit the Reflect), which dates back to Robinson (1946) that perhaps dared not use "reflection" in the heights of the Behaviorism. A myriad of other related cousins exists: PQRST (Preview, Question, Read, Summary, Test), SRR (Survey, Read, Review), PQ4R (Preview, Question, Read, Review, Recite, and Rewrite), REAP (Read to discover the author's ideas; Encode into your own language; Annotate your interpretation of the author's ideas; Ponder whether the text information is significant), and more distant relatives such as the KWL (what I Know, what I Want to learn, and what I did Learn) introduces by Ogle (1986), which emphasizes cognitive and meta-cognitive knowledge management. These strategies are designed for learning expository materials. Some, e.g., SQ3R, were introduced for remedial college reading, and later adapted for earlier grade levels, and some, e.g., KWL, were designed for primary grade instruction. To summarize, the various formulas act like external regulation schemes, similar to the concept of

an external Locus of Control (Rotter, 1966).

The second, strategy approach is to apply a particular activity or set of activities at certain points throughout the study process. A list of such strategies includes predicting, questioning (generation and answering), seeking clarifications, creating mental imagery, associating to ideas in the text, summarization, identifying text structure, looking for patterns and principles in ideas presented in a text, backward reasoning, interpreting ideas in the text, negotiating interpretations with others, activating prior knowledge, identifying word meanings, graphic organizers, and comprehension monitoring (National Reading Panel, 2000; Pressley, 2002; Trabasso and Bouchard, 2002). Several classifications are in place here. We listed single strategies but as the process of reading is a complex one, different phases of the process may benefit from different strategies. For example, activating prior knowledge is best suited at the point prior to reading a text segment rather than after reading it. The KWL does just that. It proposes application of an ordered set of strategies: prior knowledge, setting reading goal, and monitoring comprehension. So strategies can be combined as in the case of KWL above or in applying Reciprocal Teaching (Palincsar and Brown, 1984) that include prediction, question generation, summarization, and seeking clarification. Reciprocal Teaching, as its name suggests, is applied in a cooperative setting, where a small group of students jointly learn a text. Another classification is to cognitive and metacognitive strategies. KWL can be considered a metacognitive strategy that regulates the sequence of applying strategies and monitors outcomes. It does not tell us what to do when we actually read, except keeping in mind KWL, so at breakpoints we can apply it. So is RT where the group monitors the application and the interim generated mental products that are expressed in the students' discourse. A third classification is the nature of the mental products of applying strategies. It can just be a flitting or a more articulated thought that is echoed in working memory when we individually study a text. Or, it is also partially or elaborately verbally expressed during a group discourse. In both cases there are no external lasting traces, unless the individual or the group produces external representations of mental dialogues. Those can be in a form of verbal products such as summaries and written notes. Or, the external representations can be partially graphical as we underline, list our notes, or produce various graphic organizers, such as concept maps, flow diagrams, trees, or tables (see classification schemes in Horne, 1998; Robinson, 1998; Winn, 1987; also see a table of visualization methods in http://www.visual-literacy.org/periodic_table/periodic_table.html).

This brings us to describe the third approach of strategically constructing external graphical representations of the text or texts that are studied. McAleese (1998) described the process of creating a concept map "to make sense of something that is knowable" (pp. 266-267) in the sense of Novak's work (Novak, 1998; Novak and Canās, 2006). This is done within a virtual space that McAleese termed a knowledge arena. The knowledge arena consists of active internal mental (working memory) objects, external representations of the internal objects (the elements of a constructed concept map), and the dynamic interplay between the two conceptual structures. Internal objects are selected to be included in a developing concept map, so even if those objects are no longer active in working memory, they are still available for an easy map look-up and deliberation. Thus, the contents of working memory were selectively off loaded to the map. An extended concept of working memory includes the developing map (actually, parts of the map that the learner attends to) and the current active internal working memory set. Mapping construction facilitates application of several metacognitive strategies: monitoring the external construction vs. the contents of the internal working memory (self-regulation, self-confrontation and reflection in and on action) and it assists in managing cognitive load (Sweller, 1988). This is somewhat equivalent to the process of self-explanation, which is offered by Ainsworth and Loizou (2003) as one of the mechanisms underlying the function of diagrams in understanding a scientific text.

So far we have discussed the role of concept mapping in describing and elaborating a given state of knowledge. Now enters a complication: How to construct external representations when we study from a text in order to facilitate its understanding and gain new knowledge? The text is an external object presenting mainly verbal information linearly. The text's format evolved through thousands years, perhaps initially used to list properties or counts of goods and eventually depicted longer narratives that were first orally presented and so evolved other genres (Olson, 1994). Is the text format efficient? Well, we adapted over the generations. The textual format evolved and we developed strategies to cope with it. We also developed alternative presentation schemes that include visuals and graphic organizers of all sorts for general or specific purpose comprehension. But the basic format is still the verbal text and developing readers are still struggling to comprehend it and evolve to be literate. Graphic organizers aid learning from texts, as several syntheses of research indicated (Institute for the Advancement of Education Report, 2003; Gersten, Fuchs, Williams & Baker, 2001; Moore & Readence, 1984; National Reading Panel Report, 2000; Nesbit & Adesope, 2006). But how is it done? We resort to Kintsch's (1998) Construction-Integration model of compre-

hension. This model is based on two stages that describe the transformation of information into knowledge from a textual source. In the first, construction stage, the information is assembled from external sources –texts--or retrieved from the learner's knowledge-base, and is functionally interlinked (propositions network) in working memory. At this stage, there is no significant intentional filtering of the information, based on relevance and consistency. During the second, integration stage, the information details and the links between them are examined, and minor, inconsistent, or irrelevant information is filtered out (deleted or discarded). At this stage, intentional processes of information reorganization and generalization are at work, and macro-propositions are constructed and related to other macro- and micro-propositions. This process is iterative. When applied to texts, it uses natural text units, such as sentence and paragraph boundaries to mark pauses and shifts from construction to integration, as is evidenced in eye movement research (Just & Carpenter, 1980; Reichle et al, 2009). The Construction-Integration cycles describe formation and manipulation of mental entities-propositions-that form the represented meaning of a text. But the input to this process can come from additional external representations, such as maps or oral discussions, and the formed propositions may be translated to an activity such as marking the text, writing, or forming a concept map. In turn, those external traces constitute additional sources for deliberating the studied text. Such an elaborate activity should be controlled by management strategies and by the multitude of cognitive and metacognitive strategies that were mentioned above.

A construction sequence of external representations that is contiguous to SQ4R is outlined in Table 1. It consists of several generic representation formats: text, list, map and chart. In addition there are tools for editing each representation and tools for transforming one representation type into another type, similar to Conlon's (2008, 2009) and Kozminsky's (1992) proposals. In the following section we briefly present a simulated example of applying this procedure to a lengthy text. Then we discuss some design considerations for developing such tools.

2 Graphic organizers construction sequence: An example

We apply the construction sequence to an 1884 words New York Times article on global warming (Revkin, 2009), published shortly before the Copenhagen Talks and included a picture of a polar bear walking on melting ice. Upon encountering the title of the Source Text, our meager knowledge brought up Al Gore waving vigorously before a presentation of melting glaciers and recalling our warming summers. The global warming even won Gore a Noble peace prize. The first step will be to develop a Knowledge Map, using a tool like Cmap, but it will be very impoverished in this case. The second step will be to skim the article and produce a Marked-up Text, using tools available for example in word processors. We mark up headings, major phrases distinctively marking relations among phrases. From the text we extract the marked phrases and headings and produce a Phrase List (Table 2 for a fragment of the list). The list is about 580 words. It contains thirty entries, heading and selected unedited phrases. This list is further edited and reduced. It is used to develop a Question List. For example, one major question on the list is "Why the global warming issue is so complicated?" The Phrase and the Question lists can be used now to develop a Descriptive Concept Map. The phrases are extracted using an appropriate drag and drop tool to form nodes and relations in the map. Upon reading the text and consulting the trail of external representations, the descriptive map is transformed to an Organizing Map (see Figure 1). Headings or other structural clues in the source text or the other representations are specifically framed in the map, using rectangles. Content nodes are in ovals. The map is hierarchical and can "read" top to bottom, left to right, to follow the major rhetorical markers (Nathan and Kozminsky, 2004). This will be used to develop a Sentence Summary representation, using a sentence generation tool, such as in Conlon (2008). Each node is read with its adjacent nodes to form a potential sentence which can be edited by the student. The next step is to produce a Text Summary were all the sentences are coherently related (Table 3). The final step is to develop a Model Map presenting in a map format the understanding of the text and answering the major questions (see Figure 2), in this case, the complexity of the global warming issue.

As we skipped some of the details of the process because of space limitations, we should note several important points. When we skim read, for example some newspaper articles, we can skip much of the process. But deeper understanding requires a more tedious reading phase. In that case recall that we started with an 1880 words piece which amounts to close to 1000 basic and compound propositions. At the end of the process we had in the Model Map just eight nodes holding compound propositions and twelve relations among them, totaling about 20 propositions. This

drastic reduction was accomplished through application of several representation tools and the remaining Model Map represents generalizations about "the complex issue of global warming", which is referred by the rectangular node (proposition) in the map. Note that we have not linked this node to any of the other nodes. It is actually linked to all of them, representing a super-ordinate construct that subsumes all the others. Studying is mostly a bottom-up affair, unlike knowledge activation which is a top-down one. So mapping tools, primarily aimed at knowledge description, may encounter difficulties in study situations or in thinking exercises, that require abstractions (Hoz, 2009). Also, understanding is not just about the information given but also noting possibilities beyond the explicit description. In the Model Map, note that one relation is marked with a question mark ("Buildup of greenhouse effect leads to [???] a global economic slowdown"). The build up of the model let up to the expression of this possibility and its further deliberation. The external representations facilitated the construction of this relationship.

SQ4R Step	Activity	External Representations Construction and Tools
SURVEY Preview	Skim and scan the text, in order to get the general idea of the content, structure, organization, and plan of the text. Surveying the text gives the "big picture" - a framework of the main ideas, which will help to hold the details together later. Read the titles and subtitles, captions accompanying graphics, overviews and summaries.	Mark relevant headings and major content phrases in the **Source Text**. Color-distinguish between structural and content headings or phrases. Export **Marked-up Text** to **Phrase List**
QUESTION	Develop questions that provide a purpose for reading. This results in spontaneous attempts to answer the questions based on information already known (knowledge activation), and maintaining attention while later reading to find answers to questions. One method is. This will also activate prior knowledge.	Turn headings and phrases into questions. Develop a **Question List** based on the Phrase List and Marked-up Text and add partial answers based on knowledge. Edit and drag-and-drop phrases from the phrase and question list into a **Descriptive Concept Map**.
READ	Read through the sections of the text to answer questions that were developed in the previous step. Reread unfamiliar words to recover its meaning from the context. If it is still unclear, mark it down and look it up when you finish reading. Study graphics and adjust reading speed according to the passage difficulty.	Add nodes and relate between nodes in the Descriptive Map. Reorganize the map by differentially framing nodes that contain structural information to form an **Organizing Concept Map** or other schemes, like charts.
RECITE	Write summary answers to questions that were previously developed. Rephrase in once own words. If a question cannot be answered - a reread is in place, sometimes revising the questions.	Generate a **Sentence Summary** from the maps, focusing on answering previously asked questions, and then edit it to form a coherent **Text Summary**.
REVIEW	Study outlines and previously generated notes and summaries to be able to retell what was read. Recall main points and sub points in the read text and look for relationships within the content.	Edit if necessary the previously constructed external representations.
REFLECT	Linking together the information from the entire text and critically reflecting on it. This helps setting the new learned facts and arguments with already known information. Also reflection is on how to use this information and clarifies what else should be learned.	Develop a **Model Map** based on the Organizing Map and Sentence Summary.

Table 1. SQ4R study procedure, its expected activities, and external representations constructed during study

1. Global Warming
2. **Overview**
3. Global warming has become perhaps the most complicated issue facing world leaders
4. On the one hand, as an increasing body of science points to rising dangers from the ongoing buildup of human-related greenhouse gases.
5. On the other, the technological, economic and political issues have gotten no simpler, particularly in the face of a global economic slowdown.
6. through Dec. 18, 2009, President Obama and other leaders announced that no formal treaty could be produced anytime soon.
7. the leaders call for reductions in emissions and increased aid to help developing nations adapt to a changing climate and get access to non-polluting energy options.
8. This would in theory give the nations more time to work out the all-important details.
9. Negotiators would then seek a binding global agreement in 2010, complete with firm emission targets, enforcement mechanisms and specific dollar amounts to aid poorer nations.
10. At the heart of the debate is a momentous tussle between rich and poor countries over who steps up first and who pays most for changed energy menus.
11. **Background**
12. Scientists learned that humans can be a powerful influence on the climate
13. since 1950, the world's climate has been warming, primarily as a result of emissions from unfettered burning of fossil fuels and the razing of tropical forests.
14. Recent research has shown that methane, is a close second to carbon dioxide in impact on the atmosphere.
15. Scientists are struggling more than ever to disentangle how the heat building in the seas and atmosphere will affect the strength and number of tropical cyclones.

Table 2. Unedited fragment Phrase List extracted from the Global Warming article (Revkin, 2009) with three types of markings: structural heading (Bold, no background), content phrases (light background), and relationships among phrases (dark background)

3 Design considerations of Text Comprehension Tools

There are several design considerations for developing and applying a suite of tools for studying texts, based on generation of external representations, including graphical mapping capabilities: (1) As the sequence of steps for studying a text seems complex, the proposed tools should not add unnecessary external cognitive load to the comprehension processes. (2) The action sequences to apply the various tools should be perceived intuitively as part of what we naturally do when we study (e.g., marking), and add minimal tool learning overheads. (3) The tools should facilitate interactive processing, both bottom-up processing from text to knowledge representations and top-down processing from knowledge activation to the constraining the information lifted up from the text. (4) The tools should allow flexibility of transformations among the external representations they generate and ability to edit the contents of the representations. By flexibility, we mean an ability to move from any one external representation to any other. Learners tend to apply with experience a predefined sequence of operations. In fact, teaching and adopting strategies, such as SQ4R, is such a predefined sequence. While efficient at times and reducing cognitive overhead (i.e., what should I do next?), it does not allow for individual differences. An instructional module of the tools can provide information about various strategies, but also retain flexibility of action. (5) The tools should include options for generating automated views of the transformed external representations. (6) The tools should allow handling partial information. Actually a tool can technically handle large amounts of information. A text or spatial representations, such as maps, can be composed of many rolling pages, huge screens, or embedded objects. But the amount of information that we can attend to in an external representation is limited to several lines or a page view. So, transformations of partial representation to another (partial) representation should be allowed, for example, marking up only a selection of the phrases in the list tool for its transformation into a map tool.

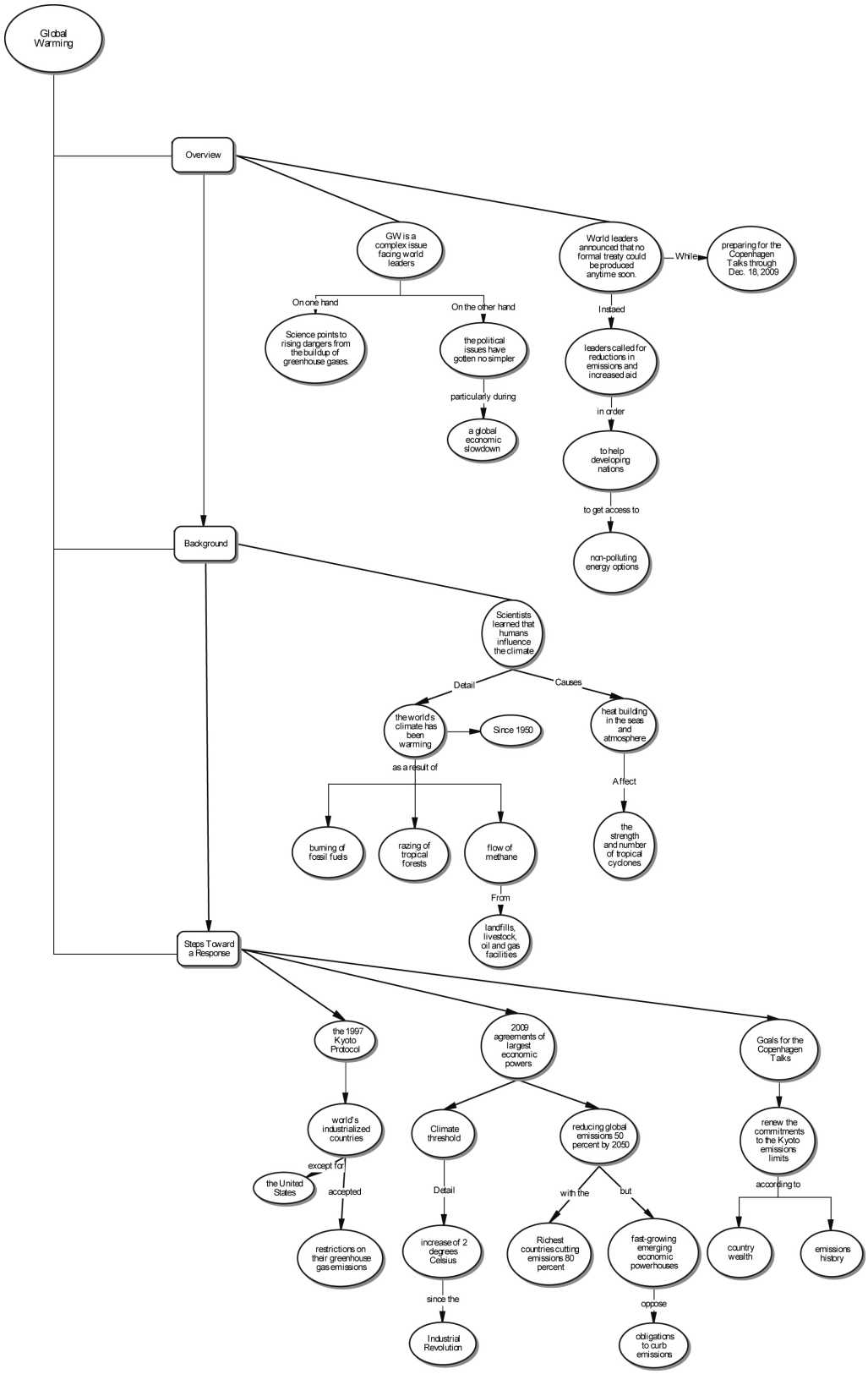


Figure 1. An Organizing Map for the Global Warming article (Revkin, 2009)

Global warming is a very complex issue, especially in the face of a global economy slowdown. Scientists claim that global warming is caused by increased build up of industrial gases that cause a greenhouse effect. World leaders can not agree on reducing emissions limits in the coming Copenhagen talks. On one hand there are the major industrial nations that produce most of the pollution but hold the majority of world wealth. On the other hand there are the fast-growing emerging economic powerhouses that don't want limits on their emissions that can effect their growth. This may result in just a minor achievement of renewing commitments to the Kyoto protocol.

Table 3. A Text Summary of the Global Warming article (Revkin, 2009)

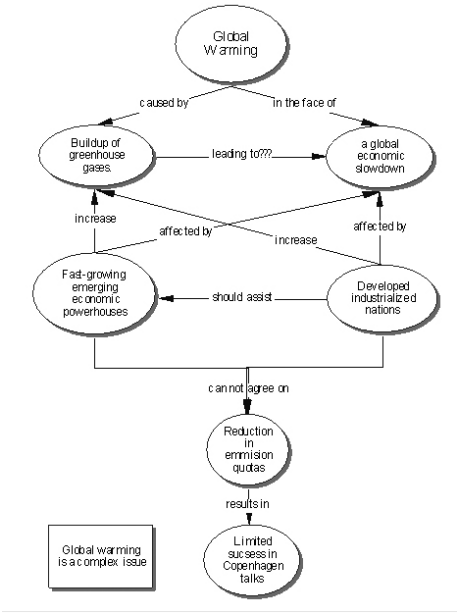


Figure 2. Model map of the global warming issue

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Concept Maps: Making Learning Meaningful
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MONITOREO DE LA ESTRUCTURA Y CONTENIDO DE MAPAS CONCEPTUALES DE CIENCIA Y MATEMÁTICAS EN SERVIDORES DE ESCUELAS INCORPORADAS AL PROYECTO CONÉCTATE AL CONOCIMIENTO

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Resumen. El Proyecto Conéctate al Conocimiento ha capacitado a miles de maestros Panameños en la construcción y uso de mapas conceptuales como medio para fomentar formas más significativas de aprendizaje para sus alumnos. Como resultado, los servidores de mapas de las escuelas que participan en el Proyecto contienen miles de mapas conceptuales producidos por estudiantes. Sin embargo, las características de estos mapas en general son desconocidas. En este estudio hemos monitoreado a lo largo de un año la calidad de los mapas contenidos en los servidores de las escuelas, utilizado herramientas desarrolladas en Conéctate para evaluar su complejidad estructural y semántica. Los resultados sugieren que, en general, los mapas de los estudiantes tienen un nivel topológico aceptable, pero su nivel semántico es bajo. Sospechamos que esto es una consecuencia de que los mapas conceptuales no son re-trabajados en las escuelas, lo que a su vez puede deberse a la falta de retroalimentación de parte de los docentes.

1 Introducción

El estudio que reportamos se llevó a cabo en el contexto del Proyecto Conéctate al Conocimiento de Panamá (Tarté, 2006), un gran esfuerzo del Gobierno Panameño de alejarse del aprendizaje predominantemente memorístico que tiene lugar en las escuelas primarias oficiales del país, moviéndose hacia formas más significativas de aprender. Los mapas conceptuales constituyen el principal instrumento pedagógico utilizado en este Proyecto ya que, bien empleada, esta herramienta facilita la organización y representación del conocimiento, y estimula la creatividad y el pensamiento no lineal (Novak & Gowin, 1984). En las escuelas incorporadas al Proyecto los estudiantes construyen mapas conceptuales utilizando CmapTools (Cañas et al., 2004). Aparte de facilitar su construcción y manipulación, CmapTools permite enriquecer los mapas conceptuales con recursos digitales, y construirlos colaborativamente con otros estudiantes a través de los servidores de mapas instalados en cada una de las escuelas participantes.

No obstante, a tres años de iniciado el Proyecto, estos servidores contenían decenas de miles de mapas conceptuales creados estudiantes, y nada se sabía de la calidad de estos mapas. El presente estudio se propuso remediar esta situación. Al hacerlo, nos enfocamos exclusivamente en mapas conceptuales de ciencia y matemáticas esencialmente porque la fuente de nuestro financiamiento, la Secretaría Nacional de Ciencia, Tecnología e Innovación, estableció este requisito; sin embargo, debido a la estrecha relación que existe entre los mapas conceptuales y el aprendizaje de conceptos de ciencia, esta restricción no le resta al estudio. En la siguiente sección describimos esta relación.

2 Mapas conceptuales y el aprendizaje de conceptos de ciencia

La relación entre los mapas conceptuales y el aprendizaje de conceptos de ciencia se remonta a principios de los años 70, a un estudio longitudinal de 12 años (Novak y Musonda, 1991) que exploró el aprendizaje de conceptos de ciencia por niños pequeños (1 º y 2 º grado). En el curso de dicho estudio, Novak y sus colegas desarrollaron los mapas conceptuales como medio para representar y seguir los cambios en la comprensión de sus sujetos de los conceptos de ciencia.

Más allá de esta conexión original, histórica, en las décadas que han transcurrido desde su desarrollo, numerosos estudios han demostrado que los mapas conceptuales pueden desempeñar un papel importante en el aprendizaje de la ciencia. Basados en la teoría del aprendizaje significativo de Ausubel (1983), los mapas conceptuales permiten "echar un vistazo" a la estructura de conocimientos del alumno, revelando no sólo lo que el estudiante ya sabe sobre un tema determinado, sino cómo lo sabe, es decir, cómo el conocimiento se organiza en su estructura cognitiva. De esta manera, los mapas conceptuales proporcionan algo así como una fotografía por medio de la cual los docentes pueden percatarse de qué conceptos conocen sus estudiantes, qué conexiones efectúan entre ellos, qué jerarquías establecen, y qué errores conceptuales tienen, todo lo cual ayuda a los docentes a trabajar para lograr el aprendizaje significativo en sus estudiantes.

En Panamá, quizá el mayor obstáculo para el aprendizaje de la ciencia sea el estilo de enseñanza memorístico que utilizan la mayoría de los docentes. Un aprendizaje basado exclusivamente en la memorización no involucra la comparación e integración de nueva información con los conocimientos anteriores relevantes, ni la atribución de significados y sentimientos personales a la información recientemente adquirida. El resultado es que la información, memorizada a punta de repetición, se almacena como islas en la estructura cognitiva del alumno, desconectada de otros conocimientos y carente de sentido y relevancia para el aprendiz. Esta situación afecta negativamente el aprendizaje al: 1) impedir la retención de nuevas ideas, 2) inhibir el aprendizaje futuro de información similar (Suppes y Ginsberg, 1963, citado en Novak, 1998), 3) restringir de la aplicación del conocimiento a nuevos contextos, 4) impedir la identificación y aclaración de conceptos erróneos, y 5) interferir con la adquisición de sentimientos positivos y la mejora del autoestima que le ocurre al alumno cuando éste se da cuenta de su propia capacidad de comprensión de un tema (Novak, 1998).

El uso adecuado de los mapas conceptuales para aprender sobre ciencia puede ayudar a poner el énfasis en las relaciones entre conceptos, más que en los conceptos aislados. Por ejemplo, después de generar un primer mapa conceptual "diagnóstico", un alumno puede proceder a mejorar su mapa cualquier número de veces, con base en la retroalimentación y la orientación ofrecida por el profesor o por otros con mayor conocimiento/entendimiento del tema. Así, el mapa conceptual inicial le sirve de andamio para seguir armando su estructura de conocimiento sobre el tema. Este proceso externo a la vez refleja el proceso interno que ocurre en la mente del estudiante cuando a su conocimiento previo, incorpora nueva información, elabora nuevas relaciones, y reacomoda o corrige relaciones previamente establecidas.

3 Métodos y Procedimientos

El trabajo consistió en monitorear mapas conceptuales generados en las escuelas del Proyecto Conéctate durante el año 2008. Se obtuvieron cuatro muestras, una en cada bimestre de los 4 que comprende el año escolar panameño; éstos se designaron M1, M2, M3, y M4. Los mapas se obtuvieron de forma remota, a través de los servidores de mapas de las escuelas participantes.

Dado que no existía un listado completo de todos los mapas conceptuales en los servidores, se utilizó el procedimiento que describimos a continuación para obtener cada una de las muestras. Teniendo en cuenta que en los servidores los mapas se organizan primero por escuela, luego por grado, y finalmente por estudiante, para la obtención de cada muestra se seleccionaron en primer lugar 50 escuelas al azar; seguidamente, se seleccionó (también al azar) un salón de clases entre el total de grupos de 4º, 5º, y 6 º en cada una de estas escuelas[1] ; y finalmente se seleccionó, al azar, un estudiante de entre todos los alumnos del salón seleccionado. Para cada uno de los 50 estudiantes así elegidos, tomamos todos los mapas conceptuales de ciencia y matemáticas contenidos en su carpeta en el servidor [2]; así se conformó cada muestra. Se desprende de este procedimiento de selección que muestras diferentes, no necesariamente iban a contener el mismo número de mapas, como de hecho fue el caso.

El análisis de los mapas involucró la aplicación de la taxonomía topológica (Cañas et al., 2006), la cual produjo información acerca de la complejidad estructural, y de la rúbrica de evaluación semántica (Miller & Cañas, 2008), que generó información sobre la calidad del contenido. En lo que sigue describimos brevemente cada una de estas herramientas.

La taxonomía topológica clasifica los mapas conceptuales en función de cinco criterios: 1) reconocimiento de conceptos, 2) presencia de frases de enlace, 3) profundidad, 4) ramificación, y 5) presencia de enlaces cruzados[3] . La taxonomía consiste en 7 niveles topológicos (0 – 6). Mapas con un nivel topológico entre 0 y 2 se consideran "pobres" topológicamente hablando, debido a la presencia de textos largos, la ausencia de palabras de enlace, y esencialmente estructuras lineales. Mapas de nivel 3 se consideran "aceptables", ya que los conceptos individuales son claramente reconocidos, no faltan palabras de enlace, y las estructuras no son lineales; no obstante, estos mapas son superficiales, sólo moderadamente ramificados, y carecen de enlaces cruzados. Los de nivel 4 mapas son básicamente "buenos" mapas; su principal limitación es que no contienen enlaces cruzados. Por último, los mapas de nivel 5 y 6 incluyen enlaces cruzados, y por lo tanto cumplen con todos los requisitos a nivel de topología para ser considerados "muy buenos" mapas conceptuales.

La rúbrica de evaluación semántica considera seis criterios: 1) relevancia y completitud de conceptos, 2) estructura proposicional correcta, 3) proposiciones erróneas, 4) presencia de proposiciones dinámicas, 5) cantidad y calidad de enlaces cruzados, y 6) organización jerárquica de los conceptos (criterio opcional). A diferencia de la taxonomía topológica en la que explícitamente se describe cada uno de los 7 niveles de clasificación, el componente semántico es un sistema de evaluación basado en puntos. Las puntuaciones totales se asocian a seis niveles de calidad de contenido: "no evaluado", "muy pobre", "pobre", "intermedio", "bueno", y "muy bueno". Las descripciones completas de la taxonomía topológica y de la rúbrica de evaluación semántica, junto con los propios instrumentos, y resultados de estudios de confiabilidad realizados con los facilitadores del Proyecto Conéctate, se pueden encontrar en Cañas et al. (2006), y Miller & Cañas (2008)[4], respectivamente.

Provistos de estas herramientas, nos propusimos caracterizar los mapas conceptuales de ciencia y matemáticas de las muestras en función de la complejidad de su estructura y la calidad de su contenido. Los resultados se presentan en la sección siguiente.

4 Resultados

Como se señaló anteriormente, se obtuvieron cuatro muestras identificadas respectivamente como M1, M2, M3 y M4. El número total de escuelas incluidas en estas muestras corresponde aproximadamente al 20% de las 700[5] escuelas participantes en el Proyecto Conéctate al momento de recogerse los datos. En esta sección se presentan, en primer lugar, los resultados de las evaluaciones topológica y semántica; después se examinan con más atención algunos aspectos semánticos específicos.

4.1 Evaluación topológica y semántica de los mapas conceptuales muestreados

El número total de mapas, junto con la media y desviación estándar para las evaluaciones topológica y semántica se resumen en la Tabla 1.

	Nivel topológico		Puntaje semántico		Tamaño de muestra
Muestra	**Media**	**Desviación estándar**	**Media**	**Desviación estándar**	***n***
M1	2.9	1.08	5.0	2.55	90
M2	2.3	1.38	5.4	2.86	84
M3	3.7	1.44	9.4	3.23	64
M4	2.5	1.15	5.9	2.41	72

Tabla 1. Media de nivel topológico y puntuación semántica de cada una de las cuatro muestras

[1]El Proyecto Conéctate dirigió sus esfuerzos a capacitar a los docentes de estos grados, principalmente.
[2]Si un estudiantes tenía más de un mapa sobre el mismo tema, se tomó el más complejo; si no tenía ningún mapa de ciencia o matemáticas, se elegía un nuevo estudiante por el proceso antes descrito.
[3]Estas son proposiciones que vinculan conceptos de diferentes sub-dominios de un mapa conceptual.
[4]El artículo Miller & Cañas (2008) presenta una versión anterior de la rúbrica que la descrita y aplicada aquí.
[5]Esta cifra es una aproximación ya que el número de escuelas iba aumentando a lo largo del año.

La muestra M1 tuvo un nivel topológico promedio muy cercano a 3, indicativo de mapas conceptuales debidamente estructurados, pero poco profundos, sólo moderadamente ramificados, y sin enlaces cruzados. En lo semántico, la puntuación media de 5 puntos ubica los mapas conceptuales de M1 en la categoría de calidad muy baja. Se obtuvieron resultados muy similares para las muestras M2 y M4, como se aprecia claramente en el cuadro. En principio, todas las muestras iban a ser obtenidas con la misma metodología. Sin embargo, circunstancias especiales que ahora describimos, nos llevaron a decidir proceder de manera diferente con la muestra M3.

Durante el tiempo que debía obtenerse la tercera muestra, Conéctate celebró su primer Encuentro de Niños Innovadores (ENI), un importante evento organizado y dirigido por estudiantes (un centenar de niños de 22 escuelas) para estudiantes (participaron cerca de 500 estudiantes visitantes de más de 100 escuelas). Las escuelas organizadoras trabajaron en pares para producir contenidos para el encuentro; entre estos contenidos se contaban un número plural de mapas conceptuales. Estos mapas fueron co-construidos por las escuelas que colaboraban, a lo largo de múltiples sesiones de trabajo, que se extendieron por un período de varias semanas.

En vista de los resultados similares de las muestras M1 y M2, y de la expectativa de que probablemente M4 saldría muy parecida (como efectivamente ocurrió), decidimos utilizar los mapas conceptuales presentados durante el evento del ENI como tercera muestra. La idea era que estos datos podrían proporcionar un contraste interesante con respecto a las otras muestras. Así, la muestra M3 estuvo constituida por un total de 64 mapas, los cuales abarcaron ocho temas principales, 6 de ellos de contenido científico. Como muestra la Tabla 1, el nivel topológico promedio de esta muestra fue de 3.7 (1.44), aproximadamente un nivel por encima de las otras muestras; del mismo modo, la puntuación semántica media fue de 9.4 (3.23), lo que coloca estos mapas dos niveles semánticos arriba, en la categoría de calidad intermedia. Ambas diferencias son estadísticamente significativas.

Los resultados anteriores sugieren que la muestra M3 podría estar representando una población diferente de las muestras obtenidas al azar de forma remota a través de servidores. Para probar esto se realizó la prueba de diferencia de dos medias entre M3 y cada una de las otras tres muestras. Los resultados para los tres pares fueron estadísticamente significativos al nivel 0.01, tanto en topología como en contenido, lo que confirmó nuestra sospecha.

En vista de estos resultados, y con el fin de comprender mejor e identificar las diferencias entre las dos poblaciones representadas por las muestras, se combinaron las muestras M1, M2 y M4 (las obtenidas de los servidores de mapas) en una sola muestra denominada, MSERV. La muestra M3 simplemente se renombró MENI, enfatizando su procedencia. La muestra combinada MSERV estaba compuesta de 246 mapas, y tenía un nivel topológico promedio de 2.6 (1.20). Niveles topológicos entre 2 y 3 son indicativos de mapas conceptuales en los que: a) todavía están presentes algunos textos largos, b) faltan algunas frases de enlace, c) la ramificación y la profundidad es mínima, y d) no hay enlaces cruzados. En contraste, el nivel topológico entre 3 y 4 para la muestra MENI apunta esencialmente a buenos mapas, estructuralmente hablando, aunque aún carecen de enlaces cruzados. En cuanto al contenido, la puntuación semántica de MSERV fue de 5.4 (2.61), correspondiente a un nivel de calidad bajo. En comparación, el promedio de los mapas del ENI, como se señaló anteriormente, se ubicó en la categoría de nivel intermedio.

Examinamos ahora más de cerca el componente semántico, con el propósito de detectar los aspectos que más contribuyeron al bajo rendimiento semántico observado en MSERV respecto a MENI. Examinando cada uno de los cinco criterios semánticos individualmente, encontramos las mayores deficiencias en tres: la relevancia y completitud de conceptos, la presencia de proposiciones dinámicas, y la cantidad y calidad de los enlaces cruzados. Las figuras 1, 2, y 3 comparan las distribuciones de MSERV y MENI en cada uno de estos criterios, respectivamente.

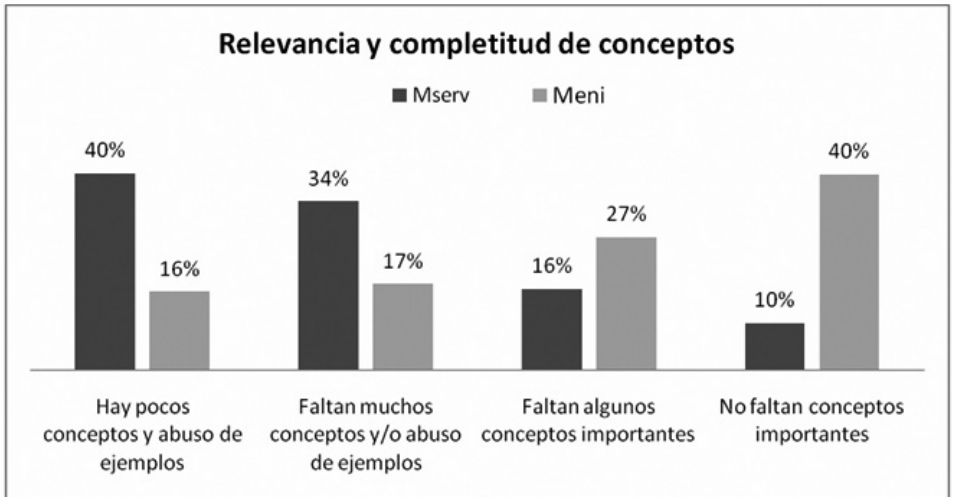


Figura 1. Comparación entre MSERV y MENI respecto al criterio de relevancia y completitud de conceptos

La Figura 1 muestra que para los mapas de los servidores, el 74% de ellos carecían de muchos conceptos pertinentes y/o utilizaban ejemplos en exceso (las dos primeras categorías de izquierda a derecha) en comparación con el 33% de los mapas del ENI. Por otra parte, sólo en el 26% de los mapas de los servidores podía decirse que faltaban pocos o ningún concepto importante en contraste con el 67% de los del ENI (tercera y cuarta categoría).

En cuanto a las proposiciones dinámicas, la Figura 2 muestra que el 51% de los mapas de los servidores contenían sólo proposiciones estáticas, en comparación con el 11% de mapas del ENI; por el contrario, el 17% de los mapas en servidores contenían proposiciones causativas, muy por debajo del 81% de los mapas del ENI .

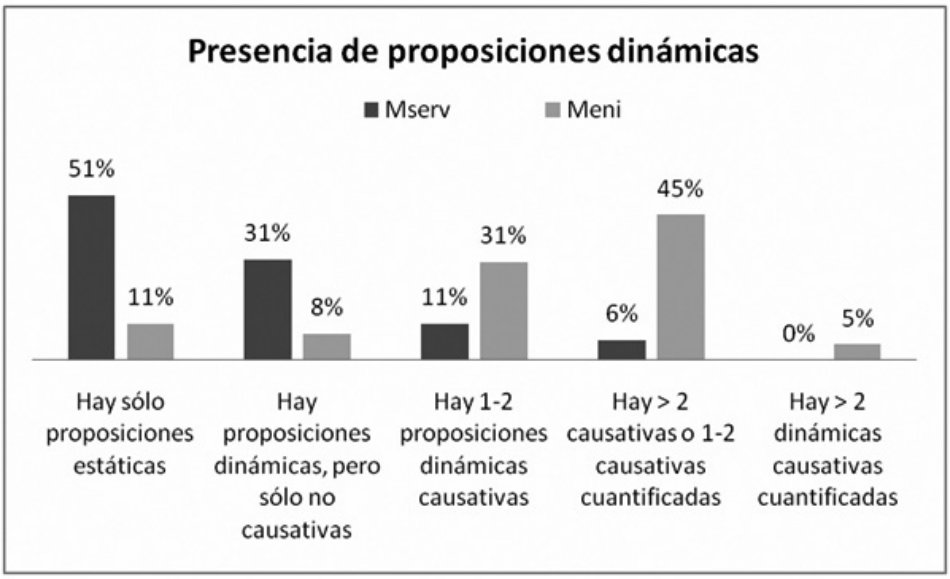


Figura 2. Comparación entre MSERV y MENI respecto al criterio de presencia de proposiciones dinámicas

Finalmente, la Figura 3 muestra la situación con los enlaces cruzados, donde el 91% de mapas de los servidores no contenían enlaces cruzados, y sólo el 7% de los que si tenían eran enlaces cruzados válidos o correctos; en cambio, el 60% de los mapas del ENI no contenían enlaces cruzados, mientras que para el 40% que sí contenían enlaces cruzados, todos eran válidos.

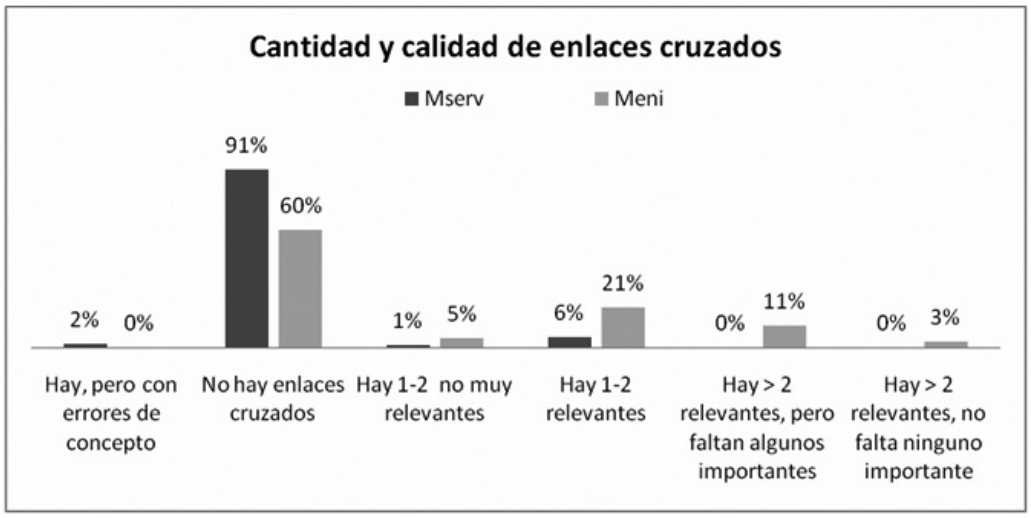


Figura 3. Comparación entre MSERV y MENI respecto al criterio de cantidad y calidad de enlaces cruzados

5 Discusión

Los resultados presentados en la sección anterior revelan pronunciados contrastes entre los mapas conceptuales obtenidos de los servidores de las escuelas y los mapas recabados del evento ENI, quedando los primeros muy rezagados respecto a los segundos, tanto en estructura como en contenido. Un examen detallado de los resultados semánticos reveló que gran parte del déficit de contenido se debió principalmente a la ausencia de proposiciones dinámicas y enlaces cruzados, dos elementos cruciales para la comprensión, organización y representación del conocimiento, particularmente el conocimiento científico y matemático.

Cañas y Novak (2006) asocian las proposiciones dinámicas con un aprendizaje profundo y significativo, mientras que las proposiciones estáticas las asocian a un aprendizaje superficial y memorístico. Esto se debe a que las proposiciones estáticas sirven principalmente para describir cosas; por el contrario, las proposiciones causativas (o implicaciones, en el caso de las matemáticas), proveen causas y explicaciones, la esencia del pensamiento científico y matemático. La escasa presencia de proposiciones causativas en la muestra de servidores (17%) parece indicativa de un enfoque de aprendizaje estático-descriptivo de los temas científicos tratados en esos mapas, mientras que la presencia preponderante de las proposiciones causativas en la muestra del ENI (81%) sugiere un enfoque de aprendizaje más bien dinámico-explicativo.

En cuanto a los enlaces cruzados, encontramos que la inmensa mayoría de los mapas de servidores (91%) no presentan enlaces cruzados. La falta de interconectividad es coherente con un pensamiento lineal, situación común entre los estudiantes acostumbrados al aprendizaje memorístico (Novak y Cañas, 2008). El porcentaje es notablemente inferior para los mapas del ENI (60%); aún así, sigue siendo considerable.

Reflexionando sobre lo anterior, algunos factores que surgen como posibles explicaciones para las diferencias observadas son: a) destreza en la construcción de mapas conceptuales, b) re-trabajo de mapas, c) publicación de mapas, y d) autonomía del alumno en relación a la construcción de sus mapas.

El bajo nivel de los mapas conceptuales en los servidores parece reflejar, por un lado, la falta de habilidad con la herramienta misma; los estudiantes no parecen ser capaces de expresar sus conocimientos sobre un tema determinado en formato de mapa conceptual. Esto no sorprende realmente. En Pankratius, 1990, Novak afirma que le toma a los estudiantes alrededor de 6 meses de práctica poder representar la complejidad de su pensamiento con precisión en forma de mapa conceptual; esto es particularmente cierto para estudiantes acostumbrados a aprender de memoria, como sería el caso de nuestros estudiantes en Panamá.

Por otra parte, Novak y Cañas (2008) han señalado que se necesitan al menos tres revisiones para lograr un mapa conceptual bueno. Tenemos fuertes sospechas de que los mapas de los servidores no han sido re-trabajados. Basamos nuestra sospecha en parte en información anecdótica, observaciones de los facilitadores en sus visitas a las escuelas; pero también en un estudio (Miller et al., 2010) cuyo propósito era precisamente explorar si proporcionar retroalimentación oportuna y pertinente a los estudiantes contribuía a aumentar su motivación para editar y revisar sus mapas conceptuales. Curiosamente, los mapas iniciales (no re-trabajados) producidos por los alumnos de dicho estudio son topológicamente y semánticamente equivalentes a los de la muestra de los servidores; sin embargo, después de que los mapas fueron revisados en respuesta a la retroalimentación proporcionada por el equipo de investigación, aparecieron diferencias significativas tanto en topología como en contenido. Para la presente discusión, estos resultados apuntan a dos escenarios (no necesariamente excluyentes entre sí): 1) los mapas en los servidores de las escuelas no suelen recibir retroalimentación, y por tanto, no son reelaborados; o bien, 2) los mapas reciben retroalimentación y son reelaborados, pero esto no resulta en mejoras significativas. [6]De los mapas del ENI podemos decir que es casi seguro que estos alumnos recibieron algunos comentarios de sus profesores, coordinadores de aula de innovación, y facilitadores del Proyecto. Este hecho, lejos de invalidar los resultados, destacaría el papel tan importante que desempeña la retroalimentación en la construcción de mapas conceptuales de calidad.

Es precisamente este proceso de revisitar un mapa una y otra vez que ayuda a los alumnos a desarrollar la habilidad de expresar la complejidad de su pensamiento en este formato. Pero también ocurre, y quizá éste sea el gran mérito de los mapas conceptuales, que al mismo tiempo este proceso puede aumentar la complejidad del pensamiento que expresa, ampliándolo, refinándolo, e interrelacionándolo. Este "valor añadido", sin embargo, depende de que el estudiante reciba información valiosa y oportuna. Por desgracia, en Panamá, éste es uno de los eslabones más débiles de nuestra cadena educativa: en nuestro sistema escolar, la retroalimentación a menudo no es nada más que un gancho ("está bien") o una cruz ("está mal"); la revisión y reelaboración de las asignaciones no es una práctica común.

Evidentemente, es imposible separar el evento de "recibir retroalimentación a un mapa" del evento de "hacer público un mapa", ya que el primero es en cierto sentido consecuencia del segundo. Esto nos lleva al tercer factor que creemos pudo haber contribuido a las diferencias entre las dos poblaciones. Los estudiantes del ENI eran conscientes de que sus mapas iban a ser "publicados", es decir, presentados ante el ojo crítico de compañeros, maestros, facilitadores y directores del Proyecto. Saber que los demás estarían examinando y quizás comentando sobre su trabajo casi con seguridad influyó en su disposición a revisar y mejorar sus mapas. En realidad, todos los mapas guardados en servidores de escuelas participantes en el Proyecto Conéctate son públicos, y podrían ser vistos y comentados por cualquiera que tenga una conexión a Internet y CmapTools instalado en su ordenador. La diferencia reside en que estos mapas conceptuales, en su mayor parte, no reciben comentarios, pues a pesar de haber logrado crear una red de cientos de escuelas, Conéctate aún no ha podido consolidarlas en una comunidad de aprendizaje viva y pujante. Así, desde la perspectiva de los autores de los mapas en los servidores, sus mapas no son públicos.

Por último, no se puede subestimar el papel que puede desempeñar la autonomía del estudiante en su motivación y en la calidad de su trabajo. El ENI fue un evento organizado totalmente por estudiantes. En la parte académica, los estudiantes de las escuelas colaboradoras decidieron todos los aspectos relacionados con sus proyectos, desde la selección del tema hasta la forma de presentación del proyecto terminado. Concretamente, si se construyeron mapas conceptuales para el ENI, fue enteramente su decisión hacerlo; el tema fue elegido por ellos, al igual que el formato de la presentación (papel, CmapTools, etc.). Uno podría imaginar que este grado de libertad, algo inusual en el rígido y altamente dirigido sistema educativo panameño, pudo bien haber contribuido, en no poca medida, al entusiasmo y esfuerzo realizado por los alumnos del ENI en construir, re-trabajar y mejorar sus mapas conceptuales.

[6]Se requeriría estudiar más esta cuestión a fin de determinar en qué medida cada posibilidad contribuye a los resultados que nosotros hemos observado.

6 Conclusiones

Este estudio involucró el monitoreo a lo largo de un año escolar completo de la calidad de los mapas conceptuales producidos por estudiantes cuyas escuelas participan en el Proyecto Conéctate. Aunque se centró en mapas de las áreas de ciencia y matemáticas, la importancia de este trabajo radica en que constituye un primer intento de medir objetivamente el impacto del Proyecto en los estudiantes (a diferencia de los docentes), específicamente en su capacidad para organizar y expresar sus conocimientos en forma de mapas conceptuales. Esto a su vez proporciona información que puede ayudar a determinar el avance del Proyecto hacia sus objetivos, y de ser necesario tomar medidas correctivas para asegurar que los mapas conceptuales realmente sean utilizados como una herramienta para el aprendizaje significativo. Por otra parte, debido a que en proyectos educativos patrocinados por el Estado este tipo de estudios generalmente no se dan, también se sienta un precedente importante en este sentido.

Nuestra investigación hizo uso de dos herramientas desarrolladas en el Proyecto Conéctate, a saber, la taxonomía topológica, con la que se evaluó la complejidad estructural, y la rúbrica de evaluación semántica, con la que se evaluó la calidad del contenido. El análisis de las muestras de los servidores indicó que los mapas típicos están topológicamente en el rango de pobre a aceptable, y semánticamente se sitúan en la categoría de calidad muy baja. En contraste, los mapas creados para el evento ENI poseen un nivel topológico que van desde aceptable hasta bueno, y un contenido semántico de nivel intermedio. Esta superioridad semántica puede ser atribuida a la presencia de más conceptos relevantes, mayor número de proposiciones dinámicas, así como la existencia de enlaces cruzados pertinentes e ilustrativos.

Al tratar de explicar estos resultados disímiles, destaca como un factor clave la reelaboración de los mapas conceptuales. Nuestros resultados sugieren fuertemente que los mapas conceptuales de los servidores no habían sido re-trabajados, una situación previamente señalada por los facilitadores de Conéctate en sus informes de visita a las escuelas. Los mapas producidos para el evento ENI, en cambio, se crearon de forma colaborativa y se re-trabajaron durante varias sesiones de trabajo.

Es nuestra esperanza que estos resultados contribuyan a que los docentes que utilizan los mapas conceptuales en su trabajo en el aula lleguen a considerarlos como algo vivo y en constante cambio… un verbo más que un sustantivo, un proceso más que un producto. El desafío para el Proyecto Conéctate es pensar en estrategias para aprovechar el potencial de la enorme red de escuelas que ha articulado para proporcionar a los estudiantes la retroalimentación que les falta a sus mapas conceptuales. Sólo cuando se haya establecido un círculo virtuoso de retroalimentación y revisión, los mapas conceptuales podrán convertirse realmente en un instrumento de aprendizaje significativo en Panamá.

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PERCEPTION OF THE USEFULNESS AND USABILITY OF CMAPTOOLS IN A UNIVERSITY-LEVEL COLLABORATIVE REMOTE LEARNING ACTIVITY

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Abstract. Our work analyzes the way in which university-level students perceive CmapTools in a remote learning context. The activity they are to perform is done remotely and in collaboration to conceptualize the main features of a course in the human sciences.

1 Introduction

According to Novak (77), a concept map makes it possible to graphically represent and organize a conceptual field as it is perceived by a person. In a pedagogical context, concept maps can fulfill several functions (Quintin 99): learning facilitator, assessment facilitator, navigation and internet search aid, communication facilitator and finally analysis facilitator or aid for structuring learning material. This last function seems the most pertinent in terms of the conceptualization activities that we ask students to perform in lab exercises for a university course in the human sciences. In this learning situation, the role of the concept map is to enable students to approach the material in an easy-to-read and global manner. The learner thus has a canvas to build upon, enrich, specify or correct as he progresses in absorbing the material. The concept map is considered to be a tool that can lead the learner to make links among the concepts he is learning and also to establish a correspondence between the previous representations he held and the new ones that are being built in his mind. The creation of a concept map may cause a cognitive conflict that brings the subject to modify his initial conception through a process of cognitive self-regulation or equilibration of cognitive structures that allows him to refine his degree of understanding. We decided to use CmapTools because it meets another specific requirement of our learning mechanism: it is possible to use this particular tool for creating concept maps remotely and in collaboration.

We want the individual representations of each member of the group to be exposed freely, then to come together to end up in a common production that has been enriched by the contributions of each member. Pudelko & al. (03) highlighted that, even though concept map tools are generally rather user-friendly, some learners have to adapt to this new graphical mode of representing knowledge that is quite different from the textual and linear representations they are accustomed to. We focused on analyzing this activity of creating a concept map remotely and, with reference to the works of Tricot & al. (03) concerning the ergonomics of computer-based learning environments, more specifically on the way students perceive the tool (its capacity to help the student attain his objective) and its usability (its capacity to be used simply and easily by the learner). To help us think about the way to analyze the use of concept maps in pedagogy, we draw from the theoretical model developed by Depover, Karsenti & Komis (07). Their model is based on the idea put forth by the distributed cognition school (Pea, 1993; Perkins, 1995) that every individual belongs to a social and materiel environment that takes part in his learning. The cognitive functioning of a learner must be considered beyond his own individual cognitive system. If learning aids can be foreseen through interactions between individuals, they can also come from the technological tools in their environment that act as an extension of their cognitive capacities.

As Figure 1 shows, Depover, Karsenti and Komis (07) distinguish cognitive potential tools from cognitive tools used for specific purposes. For these authors, the cognitive potential tool corresponds to a computerized environment whose features are such that it can be integrated into learning situations and can at the same time bring about positive effects on the learners. The authors insist on the importance of the context in which the cognitive potential tool is

to be used. Depending on the relevance of this context, a tool may be able to meet the real needs of the learners and help them develop different types of skills (usefulness). On the level of context, two additional dimensions should be taken into consideration: elements related to the material context (usability) and those related to the human context. The material context mainly concerns the accessibility the learners have to the tool and the ease with which they can use it. The human context refers more to the pedagogical action of the instructor through the learning scenario he has developed and in which the chosen tool will be implemented. The human context also takes into account individual characteristics: information about the educational background is considered in this particular research project.

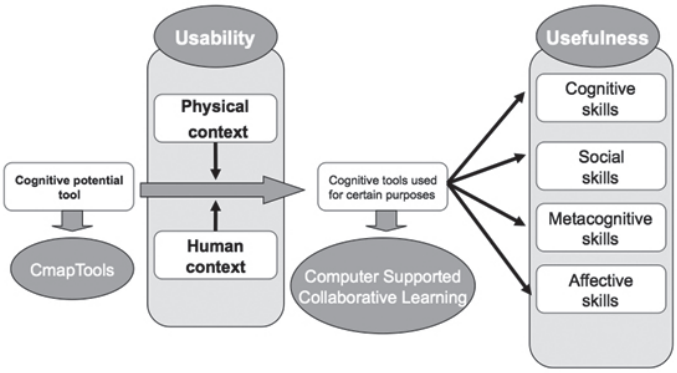


Figure 1. CmapTools in the model of the cognitive potential tool by Depover, Karsenti and Komis (2007)

2 The context of the study

The context is one of hybrid training (theoretical courses in a classroom setting and remote lab practica) for students in the 2nd year of the Bachelor in Psychology and Education. The course deals with models of teaching and learning. Concept maps are one of the means that allow students to show how they position the characteristics of the different models with respect to each other. Our work belongs to the fields of computer support for collaborative learning (CSCL) and computer-mediated communication (CMC) and our main reference model is the co-constructivist interaction model.

2.1 The teaching set-up

<table>
<tr><td>W1</td><td>W2</td><td>W3</td><td>W4</td><td>W5</td><td>W6</td><td>W7</td><td>W8</td><td>W9</td><td>W10</td></tr>
<tr><td colspan="2">Individual - Collaborative</td><td>Individual</td><td colspan="5">Collaborative</td><td colspan="2">Individual</td></tr>
<tr><td colspan="2">Phase 1</td><td>Phase 2</td><td colspan="5">Phase 3</td><td colspan="2">Phase 4</td></tr>
<tr><td>Activities 1 and 2
Profile of the learner and handling of the mechanism</td><td>Activities 3 and 4
Socialization</td><td>Activity 1
Comparison grid of families of models
Activity 2
Concept map Cmap Tools</td><td colspan="2">Activity 1
Comparative analysis of 6 families of models CmapTools</td><td colspan="3">Activity 2
Analysis of training situation</td><td>Activity 1 Assessment of knowledge</td><td>Activity 2
Self-assessment (optional)</td></tr>
</table>

Table 1. Progression of the activities by week and by phase (in grey: activities in which CmapTools is used)

Once the theoretical course is finished, the lab practica are comprised of four phases spread out over ten weeks (Table 1). Phase 1 (weeks 1 and 2) corresponds to (activity 1) handling the training mechanism and the e-learning platform that supports it (Esprit[1]), allowing learners to become familiar with the tools for remote communication and collaborative work. This is also the moment (activity 2) to collect information on the individual characteristics of the learners using various questionnaires: personal profile, learning style, motivation, feeling of personal efficiency.

[1]Esprit: http://ute3.umh.ac.be/esprit

During activities 3 and 4, the learners discover who their fellow team members are and use CmapTools to describe the team. This collective activity enables them to become familiar with its use.

Phase 2 (week 3) asks students individually to compare three families of pedagogical models from the six presented during the theoretical course (Behaviorism and neo-behaviorism, Socio-cultural approach and distributed intelligence, Constructivism and socio-constructivism, Mastery learning, Gestalt and information processing, Social learning). The comparison is made using a grid (activity 1) that contains a series of criteria to highlight their specificities. Then the students - still individually - represent the comparisons made in the grid in the form of a concept map edited by CmapTools (activity 2).

Phase 3 (weeks 4, 5, 6, 7 and 8) is collaborative. Groups of three students are formed based on their participative learning style (see description of experimental variables). Starting from their comparison of certain families of models, they must collectively design a map with CmapTools that summarizes all of the families of models from the course (activity 1). In an online forum set up to this effect, they discuss their choices and the way to proceed. Three steps are foreseen to carry out their analysis. The first is to compare the maps of the models that the members of the team have in common and to annotate the maps that they do not have in common. The second step is to identify relationships of similarity and opposition between the six families of models; at least four links must be made between the families of models. The third step is to write a team report, related to the concept map, in which the similarities and differences between the six families of models are highlighted. The teams must choose the ten links that they consider the most important for characterizing the models and they must support the choice of these links in their report. Activity 2 of this third phase asks learners to watch four video segments of spelling lessons, after which, in order to apply the theoretical aspects of the course in a real situation, the students must identify in these film segments the concepts from the pedagogical models that seem to them to be best represented.

Phase 4 (weeks 9 and 10) is individual and demands that learners carry out (activity 1) a certain number of compulsory assessments (knowledge test, opinion test,…) and invites them optionally (activity 2) to prepare for the final examination using a self-assessment questionnaire.

2.2 The experimental set-up

The dependent variable of our analysis is the opinion of learners on the usefulness and usability of CmapTools in the collaborative activity they are carrying out remotely. The independent variable of the experimental set-up (Table 2) is that the learners are first-time university students (N=126) or continuing education students (N=54) and are participating in the same remote training mechanism.

TYPE OF TRAINING:	*Teams*	*Subjects*
First-time university education	42	126
Continuing education	18	54
	60 teams	***180 subjects***

Table 2. Breakdown of the two experimental groups

3 Research questions and methodology

3.1 The research questions

Our intention, with the questions listed below, is to find out how students perceive the usefulness and usability of CmapTools. The main questions presented here are inspired by the works of Dillenbourg (02), which underline the effect of the structuring of interactions on the efficiency of collaborative learning.

Q1. What is the perception of the usefulness and usability of the CmapTools software for all of the students?

Q2. Do the first-time university students have a perception of the usefulness and usability of the CmapTools software that is different from that of students in continuing education?

3.2 The methodology

Information was gathered using various questionnaires filled out by the learners during the course of their training. To measure the perception that the learners have of the tool, we used the Davis questionnaire (89) composed of 12 questions spread out equally between usefulness and usability. This questionnaire has been translated from English into French and adapted for CmapTools. We felt it was useful to add three additional questions to the initial twelve: these cover the online use of the tool (Q6), the collaborative activity (Q7) and the interactions between team members (Q11). The students must indicate their opinion on a 5-level Likert scale ("totally disagree" to "totally agree").

4 Results of the experimental study

Our analyses cover two lines. The first deals with the overall perception that university students have of the usability and usefulness of CmapTools. The second deals with the difference in perception between our two groups of students with different educational backgrounds (first-time university students and students in continuing education). We will only present the items for which a significant difference was observed.

4.1 For all of the students

Table 3 reveals that the majority of learners have a positive opinion about the use of CmapTools. More specifically, when we look at the "totally agree" column, we see that the questions for which we obtain the best results (the only ones that are higher than 20%) are related to usability: CmapTools "is easy to use to design a concept map" (Q4: 28.8%), "is a tool that I find user-friendly" (Q1: 25.4%), "seemed easy to use" (Q2: 21.5%), "is a tool through which it was easy for me to become skillful" (Q5: 21.5%). This bears witness to the idea that, on the whole, learners agree that the tool is not only easy to learn and to use, but also that it does indeed enable them to attain one of the objectives - designing concept maps.

In terms of usability, we can thus say that the appreciation of the learners is rather positive. Figure 2, in which we have grouped the items according to their percentage of positive opinions (total of the "agree" and "totally agree" percentages), shows this and more: not only are the positive opinions quite high, but also relatively equal from one column to another.

As far as negative opinions are concerned, very few learners chose the level "totally disagree". The highest scores for these items are: "allowed me to work on a common map at the same time as my fellow team members" (Q7: 8.5%) and "makes it possible to interact with my fellow team members" (Q11: 5.1%). These two items are both linked to collaborative use. This could mean that the collaborative and online use of CmapTools is somewhat difficult and that it may not be easy to work at the same time as fellow team members on a single map. Answering the open questions on the questionnaire, the students say that it is difficult to work on a collective map without seeing each other and some think that the work would have been more interactive if it had been done face-to-face (in the library, for example) to discuss the various points.

In Figure 2, it is clear that these (Q6, Q7 and Q11) are indeed the three items that get the most negative (in bold) reactions. By testing the homogeneity of opinions using the χ^2 test, we can show that, for the items related to collaborative use, there is a significant difference observed for Q6 "online use seems easy to me"; $X^2 = 13.849$; TS = .008). The opinions given concern the tool's capacity to be used online easily, which is complex undoubtedly due to network problems rather than to problems with CmapTools itself. So it is the nature of the collaborative activity that appears to complicate the task and not necessarily the software. It seems important to take into account the difficulties associated with working in a team on a single task, which required more coordination and additional means of communication. Tools should not increase this difficulty but reduce it as much as possible. In light of this particular finding, CmapTools does not seem to help on this level - but at the same time it is not an impediment, as can be seen through various positive reactions.

		Totally disagree	Disagree	Neither agree nor disagree	Agree	Totally agree	χ^2 Test	
		Negative opinion			Positive opinion		χ^2 - sign	
Usefulness	Q8. That allows me to perform my tasks more quickly.	5.1 %	18.1 %	37.9 %	34.5 %	4.5 %	8.418	**.007**
	Q9. That improves the quality of my work.	1.1 %	9.6 %	31.1 %	46.9 %	11.3 %	8.090	.088
	Q10. That increases my productivity.	1.7 %	14.7 %	45.8 %	32.2 %	5.6 %	12.869	**.012**
	Q12. That makes it easier to do the task that has to be performed in this activity.	0.6 %	8.5 %	16.4 %	58.2 %	16.4 %	9.104	.059
	Q13. That improves the efficiency of my learning.	1.7 %	13.0 %	28.8 %	47.5 %	9.0 %	8.580	.073
	Q15. That will be useful to me in my education.	2.3 %	11.9 %	37.3 %	37.9 %	10.7 %	5.569	.234
Usability	Q1. That I find user-friendly.	1.7 %	15.8 %	15.3 %	41.8 %	25.4 %	7.479	.113
	Q2. That seemed to me to be easy to use.	1.1 %	13.0 %	16.4 %	48.0 %	21.5 %	2.955	.565
	Q3. With which interaction is clear and understandable.	1.1 %	9.0 %	26.0 %	46.3 %	17.5 %	1.416	.841
	Q4. That is easy to use to design a concept map.	0.0 %	2.8 %	10.2 %	58.2 %	28.8 %	3.297	.348
	Q5. Through which it was easy for me to become skillful.	0.6 %	7.9 %	17.5 %	52.5 %	21.5 %	2.796	.593
	Q14. With which I could interact with flexibility.	2.3 %	11.9 %	32.2 %	44.1 %	9.6 %	7.414	.116
Collaborative use	Q6. Whose online use seems easy to me.	3.4 %	19.2 %	28.2 %	35.0 %	14.1 %	13.849	**.008**
	Q7. That allowed me to work on a common map at the same time as my fellow team members.	8.5 %	19.8 %	22.6 %	30.5 %	18.6 %	5.805	.214
	Q11. That makes it possible to interact with my fellow team members.	5.1 %	18.1 %	37.9 %	34.5 %	4.5 %	7.085	.131

Table 3. Occurrence of the answers to the questionnaire related to the usefulness and usability of CmapTools –χ^2 value and degree of significance

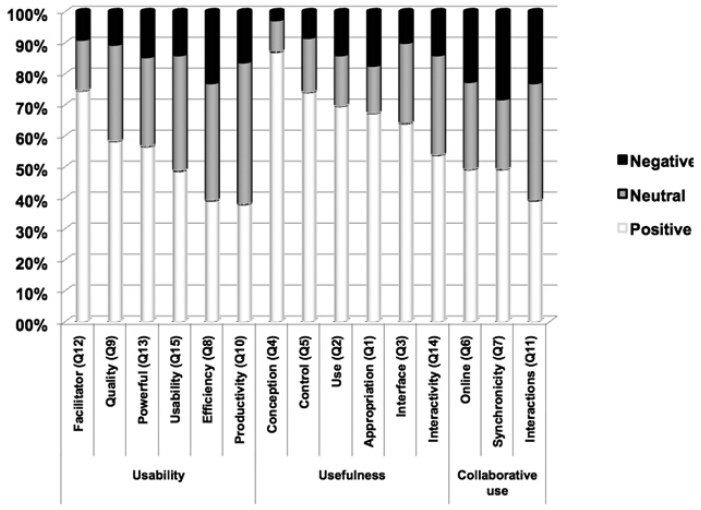


Figure 2. Hierarchy of the items according to positive and growing appreciation of the usefulness, usability and collaborative use of CmapTools

In terms of the usefulness of CmapTools, in their answers to the open questions, it is above all the cognitive and esthetic potential of the tool that students put forward: “I think this program is rather convincing. It lets us use our analytical skills while trying to tap into our artistic potential and eye for detail to produce a map that is both clear and pleasant to look at.” (Alain). In their opinion, making the concept map gives them the chance to organise, to establish a hierarchy and to assimilate the various notions brought up in the course: “I plan to print out the concept maps and use them to help me study for the Educational Psychology exam because they are a good summary of the material.” (Estelle).

As for the answers where students were to give their opinion using a Likert scale, we see in Table 3 that the degrees of significance yielded by the χ^2 test are almost all significant (Q8 “allows me to perform my tasks more quickly”; $X^2 = 8.418$; TS = .007) and (Q10 “increases my productivity”; $X^2 = 12.869$; TS = .012) or nearly significant (Q12 “makes it easier to do the task that has to be performed in this activity”; $X^2 = 9.104$; p: .059) ; (Q13 “improves the efficiency of my learning” ; $X^2 = 8.580$; p : .073) and (Q9 “improves the quality of my work”; $X^2 = 8.090$; p: .088). Hence we can say that overall the usefulness of CmapTools is considered differently by learners: some have a positive opinion of it (many “agree”), while others have a more mixed opinion (many “neither agree nor disagree”). Figure 2 clearly shows this contrast between positive opinions (in white) and mixed opinions (in grey). There seem to be divergent opinions among learners as to the effect of CmapTools on fulfilling tasks, whether in terms of productivity or efficiency or both together.

We can say then that, all in all, learners have a positive and unanimous opinion on the usefulness of CmapTools, but a contrasting opinion (positive or mixed) as to its usability, and a rather negative opinion of its collaborative use. We will see below that this disparity in opinions as to the pedagogical relevance of CmapTools can be better understood when the educational background of the learners is taken into consideration.

4.2 Depending on the educational background of the learners

The following analysis in Table 4 shows that students in continuing education express opinions that are significantly more positive than first-time university students in terms of the usability of CmapTools [Q1 – 101.21 >89.32; p: .039 (TS)] and its collaborative use [Q6 – 109.34 >81.21; p: .001 (TS), Q7 – 101.34 >84.05; p: .033 (TS) and Q11 – 102.68 >83.11; p: .022 (TS)]. On the other hand, in terms of usefulness (Q9 and Q13), the first-time university students have significantly more positive opinions [Q9 – 93.07 >76.81; p: .035 (TS) and Q13 – 93.95>76.08; p: .026 (TS)].

First-time university students appear to be more skeptical about the pertinence of CmapTools for favoring cognitive skills [improving the quality of work (Q9) and the efficiency of learning (Q13)]. Continuing education students are more focused on easy implementation from the perspective of general functioning (Q1) and online use (Q6) and on the facilitation of group work whether it is on the level of interactions (Q11) or on the level of simultaneous work on a common map (Q7). For this latter category of students, their focus on the material context (Depover & al., 2006) can be understood by their need for tools that simplify the task. These are adults who have taken up university studies later in life and who work during the day and study at night. This group of students needs tools that are easy to use and that favor remote communication and group work.

Cmap Tools is a tool:	Initial education	Continuing education	Significance	Item related to
Q1 - that I find user-friendly	89.32	**101.21**	**.039 (TS)**	usability
Q6 - whose online use seems easy to me	81.21	**109.34**	**.001 (TTS)**	collaborative use
Q7 - that allowed me to work on a common map at the same time as my fellow team members	84.05	**101.34**	**.033 (TS)**	collaborative use
Q9 - that improves the quality of my work	**93.07**	76.81	**.035 (TS)**	usefulness
Q11 - that makes it possible to establish interactions with my fellow team members	83.11	**102.68**	**.022 (TS)**	collaborative use
Q13 - that improves the efficiency of my learning	**93.95**	76.08	**.026 (TS)**	usefulness

Table 4. Values of the rank test (U-Mann-Whitney) according to the educational background of the learners

First-time university students seem to be less sensitive to these constraints: they are more concerned with finding tools that are efficient in making their learning easier. These learners are more focused on the pedagogical efficiency of the tools probably in part because they have more time to solve technical difficulties but also because they can carry out the collaborative aspects using means other than those provided by the tool itself. These first-time learners generally have more opportunities to meet each other in person whereas the learners in continuing education count on the proper functioning of the tool to enable them to carry out the collaborative activities. This could explain the importance they place on the proper functioning and the relevance of CmapTools in the pedagogical context that interests us.

5 Conclusions and perspectives

Overall, the usefulness of the tool is confirmed. Opinions on its usability are mixed and those related to the collaborative use of CmapTools are less positive. The learners find the tool easier to use than efficient for learning, but they also find it complicated to implement in groups remotely.

Depending on the educational background, the learners are more sensitive to the usability or to the collaborative use of the tool to the detriment of its usefulness when they are faced with a heavy organizational burden due to tight schedules. This is indeed the case of our students in continuing education. The first-time university students are concerned with the usefulness of the tool to the detriment of its collaborative use.

Usability seems to be important for all the students, especially for those who have the heaviest workload, like our continuing education students. In our research, students who are more sensitive to the usefulness of the tool for its relevance to learning are those with the lightest workload: the first-time university students. The collaborative use of CmapTools appears difficult to implement. However, it would seem that this is due to the inherent difficulties of group work rather than to the characteristics of the tool itself, which, incidentally, are perceived positively.

To further our research on the adequacy of CmapTools with respect to the needs of our learners with varying profiles and the type of remote collaborative scenario that we set up, it would be useful to refine our observations through a more qualitative analysis of the procedures used by learners in terms of designing concept maps. We should combine trace analysis with the analysis of the discussions in the forums, which would enable us to better understand the choices that were made. This could be enriched with semi-guided interviews of learners in view of an even deeper understanding of the pedagogical “added value” that they associate with this technological tool.

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PROFESSIONAL DEVELOPMENT FOR KINDERGARTEN TEACHERS: CONCEPT MAPPING

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Abstract. The purpose of this paper is to describe the professional learning of kindergarten teachers as they acquire the necessary knowledge and skills to use concept mapping for both instructional planning and as an instructional strategy to promote children's conceptual development. A research center located in the southeast of the United States of America is currently conducting a series of professional development sessions with kindergarten teachers from one large, urban city focused upon helping young children build core knowledge essential to school success. Concept mapping has been introduced in these training sessions, with a survey and questionnaire administered at the conclusion of the fifth meeting. The results of this study will be used to plan the final training session for the participants this school year, as well as to plan the incorporation of concept mapping into professional development in the upcoming year

1 Background

An American research center located in a southeastern state has the mission of strengthening the quality of education in the state by planning and developing collaborative programs and activities among universities, community colleges, and public schools. One project working towards this mission places a team from the research center in partnership with a large, urban school district in an effort to develop a seamless continuum of transitions beginning with prekindergarten and moving through 3rd grade. The research team is composed of five professionals who contribute expertise in various areas of research: educational leadership, early childhood education, and research methodology. Three team members have extensive experience conducting practice-focused research with teachers in classroom contexts. This research team knows that many children enter school educationally disadvantaged, especially when compared to their more affluent peers (West, Denton, & Germino-Hausken, 2000). Access to knowledge building experiences, where books and instructional materials of high-quality are readily available, differs greatly among neighborhoods of varying income levels (Neuman & Celano, 2001). This differential access is an issue because it impacts children's background knowledge, which greatly impacts their school success (Duke, 2000). "Impoverished early environments are powerful predictors of adult failure on a number of social and economic dimensions. Impoverishment is not so much about the lack of money as it is about the lack of cognitive and non-cognitive stimulation given to young children" (Heckman, 2006, p. 3). In an effort to provide all district kindergarten children with cognitive stimulation, the research team implemented a series of professional development sessions designed to provide kindergarten teachers with the knowledge and skills needed to use concept mapping as both a planning and an instructional tool.

Concept maps are graphical representations of knowledge that help children visualize and understand the relationships among hierarchical concepts (Novak and Cañas, 2008). Linking words on these maps show the relationship between two concepts, and these can be read as complete thoughts. Having teachers use concept maps as a planning tool helps them see the large picture of connections and relationships among the concepts and skills they are planning to teach, thereby helping them make these associations more explicit during instruction. Using concept mapping as an instructional tool provides children with a visual representation of the information they are learning. Dual coding theory recommends using non-linguistic instructional tools such as graphic organizers and concept maps to assure that knowledge is stored in children's memories in multiple ways (Sadoski & Paivio, 2001). The purpose of this paper is to describe the professional development of teachers as they learned how to use concept mapping as a tool to organize their own knowledge to plan instruction for children, as well as a tool to help children visualize and make connections

among the concepts they are learning.

2 Professional Development for Kindergarten Teachers Using Concept Mapping

A series of professional development sessions was provided for the kindergarten teachers in spring 2010. Each session ranged from 1 to 1 ½ hours. In February and April, a full day of training was provided with three consecutive sessions given each day. Two training session were provided in the month of February, giving the teachers a total of nine professional development sessions they could attend January through April of 2010 (Table 1). Attendance ranged from 35 to 87 people per session.

As the research team planned the series of training sessions the same question kept arising: How can professional development best be designed and delivered to maximize kindergarten teachers' use of concept mapping? The team knew that to be successful, the information presented to the teachers must focus on the content that they are supposed to teach, must be linked to daily classroom practice, and must be sustained over time to affect student learning (Gusky, 2000). With this in mind, the research team planned the training sessions at least once per month to provide the opportunity to work with teachers over time. Each session focused upon the current theme from the teachers' science and reading series to assure that the participants found the content relevant. The research team extended ongoing support to teachers by providing contact information to answer questions between training sessions.

3 Professional Development Strategies

The monthly professional development sessions provided to the kindergarten teachers incorporated several different strategies for teaching about concept mapping. According to Novak and Gowin (1984), learning should be considered an active process that involves acquiring, creating, and using knowledge. Therefore, each session for the kindergarten teachers incorporated a variety of professional development strategies to assist the teachers in acquiring the knowledge and skills needed to create and use concept maps in their own classrooms. Table 1 shows the date of each training session, along with the professional development strategies used at each session.

	Dates of Professional Development Sessions								
Professional Development Strategies	**1-27**	**2-16**			**2-24**	**3-31**	**4-27**		
Provide Computer-generated Concept Map	✓	✓	✓	✓	✓	✓	✓	✓	✓
Provide Pictures to Make a Concept Map	✓		✓	✓	✓	✓	✓		✓
Present Slide Show on Concept Mapping				✓					✓
Display Concept Map Using Pictures			✓	✓	✓	✓	✓		✓
Show Video Clips of a Class Making a Concept Map		✓							
Engage Participants in Creating a Concept Map			✓	✓					✓

Table 1. Kindergarten Professional Development Strategies by Session

3.1 Provide Computer-generated Concept Map

Individuals learn in many different ways, some through visual stimulation and others through auditory learning (Silver, Strong, & Perini, 2000). With differing learning styles in mind, the research team introduced concept mapping to the teachers at the first session by presenting and explaining several computer-generated concept maps. One computer-generated map presented to the participants at this initial training session (Figure 1) was a planning tool for their current science theme. Providing teachers with computer-generated concept maps was the only professional development strategy that was used during each of the nine training sessions.

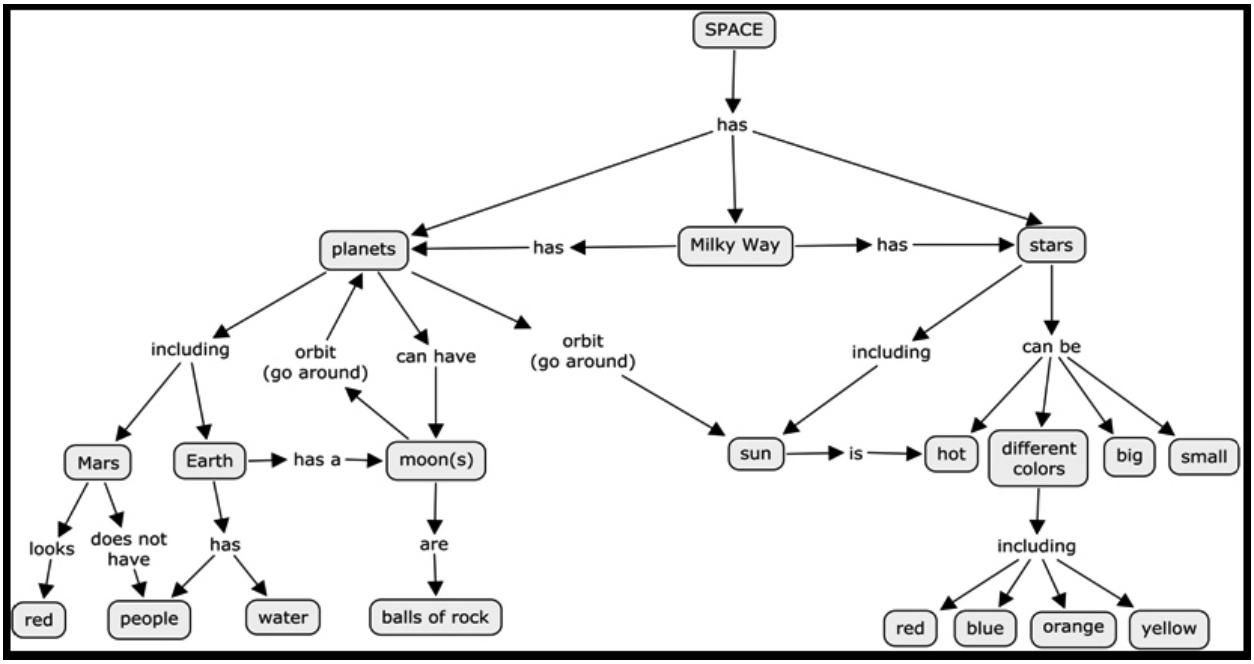


Figure 1. Computer-generated concept map provided January 27, 2010

3.2 Provide Pictures to Make a Concept Map

The second most frequently used professional development strategy was providing the participants with color pictures to use in making concept maps with their students. As many of the students in kindergarten are non-readers, they are better able to understand and learn from the classroom concept maps if they contain pictures as visual tools (Cassatta-Widera, 2008). Pictures matching one of the current instructional themes (Figure 2) were provided as handouts in seven of the nine sessions to encourage the creation of concept maps with children.

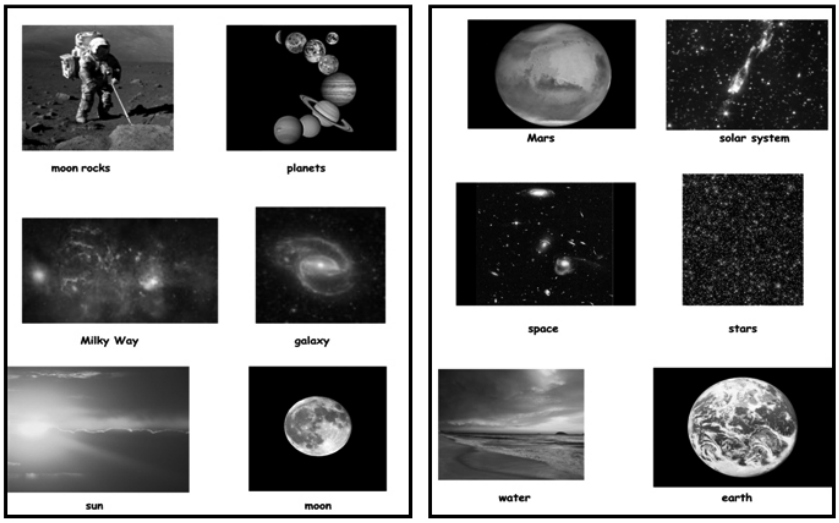


Figure 2. Pictures to make a concept map provided January 27, 2010

3.3 Present Slide Show on Concept Mapping

To prepare themselves to provide participants with a solid understanding of concept mapping, the research team met with Dr. Nancy Romance, a professor at Florida Atlantic University in Boca Raton, Florida, to develop their own understandings of concept mapping. After this meeting, the team designed a slide show presentation for the kindergarten teachers' second day of training. This presentation contained information explaining what a concept map is and how concept mapping can be used by teachers as a tool for planning, instruction, and assessment. A sample slide from this presentation is shown in Figure 3. The strategy of presenting a slide show presentation on concept mapping was used on the second day of training in February, and was used a second time at the full training day in April to review what the teachers had been learning about concept mapping. Figure 4 shows a sample slide from this review on April 27, 2010, with sample responses from teachers included.

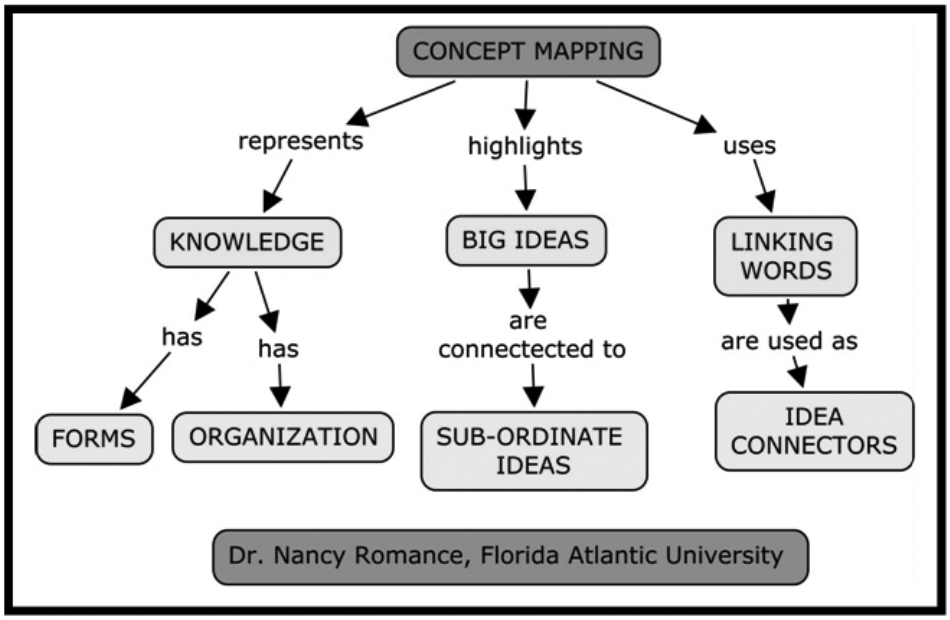


Figure 3. Concept map of concept mapping provided February 16, 2010

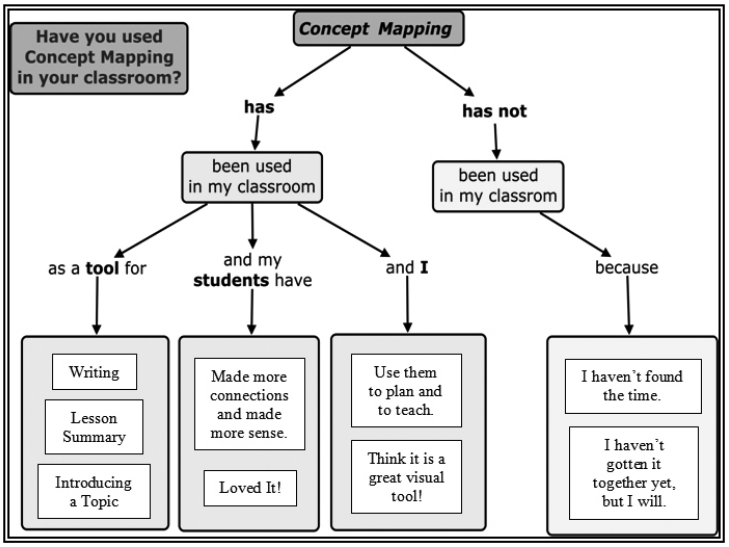


Figure 4. Concept map reflection activity from April 27, 2010

3.4 Display Concept Map Using Pictures

Starting on the second day of training, displaying a concept map using pictures became a strategy that the research team implemented at each professional development session. On the first day of training the team noticed the teachers' preoccupation with the software needed to create computer-generated maps. Even though pictures were provided to the teachers at the January meeting, along with an explanation of how to use these pictures to create a map with the students on chart paper, the research team decided that having a visual model would be beneficial to the teachers. Figure 5 shows a concept map using pictures that was displayed at the training on March 31, 2010.

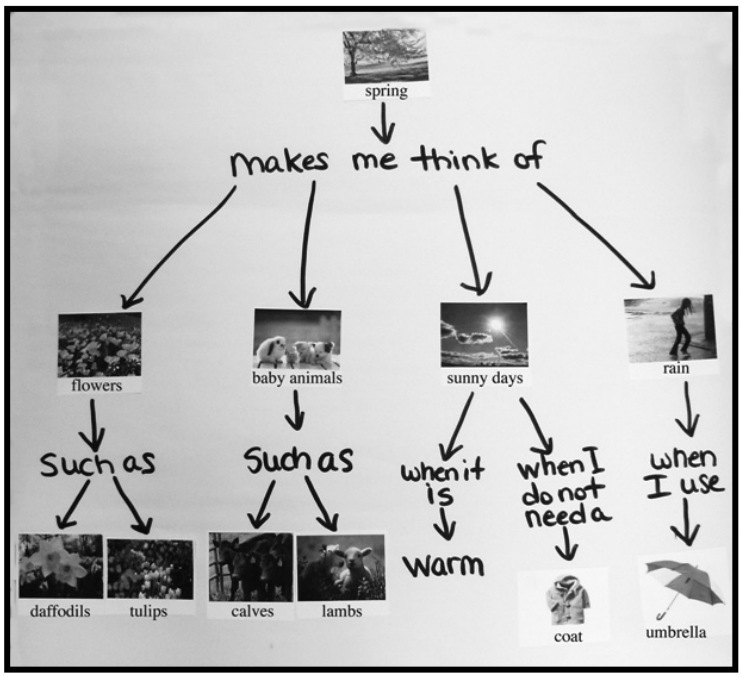


Figure 5. Concept map using pictures displayed March 31, 2010

3.5 Show Video Clips of a Class Making a Concept Map

To allow participants to observe a teacher creating a concept map with a class of pre-readers, a lesson was video-taped and edited into clips. The first clip focused on the teacher asking the class the focus question, "What do you know about birthdays?" The second clip showed the teacher adding new concepts that the children named to the map using pictures that she had printed before the lesson. If a child named a concept that the teacher did not have the picture to match, the teacher wrote the idea on a sticky to print a picture later. There were a total of six video clips shown. The final clip showed the teacher reviewing the entire map with the children. She then ended her lesson with an explanation of the purpose of creating a concept map to the children as helping them organize and remember everything they were learning. During the all day training on February 16, 2010, the kindergarten teachers watched each of these clips, engaging in discussion questions between each clip. This professional development strategy was only used during the one training session in February, with 87 participants in attendance.

3.6 Engage Participants in Creating a Concept Map

Based upon the meeting with Dr. Romance from Florida Atlantic University, the research team decided that one useful strategy for learning about concept mapping is to work in small groups to create maps. The team engaged the teachers in creating their own maps on the second day of training. Providing time for the teachers to work together to use their newly learned knowledge about concept mapping to create their own maps did appear to be useful to the teachers. Un-

fortunately, this strategy took a great deal of time. Due to time constraints, this strategy was only implemented during each of the two all day training sessions.

4 Assessment

Most professional development sessions begin and end with an evaluation of individuals' reactions to the workshop. This typically provides very little useful information for planning future professional development (Guskey, 2000). During the final session of the fifth professional development training day on April 27, 2010, teachers were asked to fill out a survey and a questionnaire. Of the 81 participants present this day, 39 consented to participate in this study. Information was gathered from these participants with the goal of answering the following research question: How can professional development best be designed and delivered to maximize kindergarten teachers' use of concept mapping?

4.1 Teacher Survey

A 10 item survey was used to gather information about the participants and the effectiveness of different training strategies in relation to teachers' use of concept mapping. Participants included 36 females and 3 males. The participants had an average of 11 years teaching at the kindergarten level, with years of experience ranging from 2 to 41. Along with demographic information, the survey provided information on how often and in what ways teachers were using concept mapping in their classrooms. Of the 39 participants, 11 had never used concept mapping, 10 used it once a month, 15 used it twice a month, and 3 used it weekly. More participants use concept mapping for instructional purposes, 28, than for planning purposes, 22.

Aside from learning how and how often teachers were using concept mapping, the research team asked questions to identify the professional development strategies that were most useful in helping participants understand and use concept mapping in their classrooms. Teachers reported the following professional development strategies as most useful in helping them understand concept mapping: Seeing examples (14 responses), making concept maps during training (6), watching video clips of a concept mapping lesson (3), and the slide show presentations on concept mapping (2). Teachers each listed the training activity that most encouraged the use of concept mapping in the classroom: Receiving color pictures (12 responses), seeing examples (7), creating maps at training (3), and watching video clips (2). Several individual responses included benefits to children such as increased vocabulary, enhanced concept development, and that they serve as visual tools for writing. One survey question asked participants to rank training activities from the different professional development sessions from highest to lowest based upon their usefulness in helping a teacher use concept mapping in the classroom. All six of the professional development strategies described in section 3 of this paper were ranked as the highest and the lowest by at least two teachers. Participants ranked watching video clips of a teacher using concept mapping (13 responses), receiving printed pictures to match concepts in a book (12), and seeing examples of concept maps that are created with pictures (10) to be the three most useful strategies for encouraging the use of concept mapping in their classrooms. The Least effective strategy reported was experiencing a PowerPoint presentation on the topic of concept mapping (22), despite the fact that two participants listed that as the most helpful professional development strategy.

4.2 Stages of Concern

When adults are faced with change, they display many different reactions. The Stages of Concern Questionnaire was given to the participants to assess their concerns about the use of the innovation of concept mapping in their classrooms (George, Hall, & Stiegelbauer, 2006). Stage 0 demonstrates awareness concerns, and there is typically little involvement with the innovation at this stage. Stage 1 demonstrates information concerns where the individual needs specific details about the innovation. Stage 2 demonstrates personal concerns on how the innovation will affect the individual and his/her job. Stage 3 demonstrates management concerns typically dealing with the organization of time and materials needed to implement the innovation. Stage 4 demonstrates consequence concerns showing worry over the impact of the innovation on the students. Stage 5 demonstrates collaboration concerns where individuals want to work with others to implement the innovation. Stage 6 demonstrates refocusing concerns where individuals modify

innovation implementation for overall improvement (Hall, George, & Rutherford, 1986). Teachers' apprehensions towards the change process typically reflect levels of concern about their abilities to implement the new innovation (George, Hall, & Stiegelbauer, 2006). Identification of the stages of concern will assist the research team in planning future training sessions tailored to meet the needs of teachers at each of the stages.

4.2.1 Peak Stage Score Interpretation

Of the many ways to analyze the scores on the Stages of Concern Questionnaire, the research team selected the Peak Score Interpretation. The highest stage score for each individual is identified. If a second stage scores within two percentile points, both stages are noted. Of the 39 participants, 31 had peak scores in Stage 0 showing them to be at the awareness stage of this innovation. The higher the Stage 0 score, the more the person is indicating that they are facing other tasks of great concern. Of the 31 Stage 0 peak scores, 23 had a score of 90 percentile points or higher. Six of the 31 individuals with Stage 0 peak scores had a second score within two percentile points. Three individuals scored high in Stage 1 showing a desire to learn more about concept mapping. One individual scored high in both Stages 2 and 3, showing both personal and management concerns with concept mapping. The final two scores to double peak with the Stage 0 scores were both high at Stage 6. This tailing up at Stage 6 can be interpreted as resistance to the innovation.

Five participants had a peak score in Stage 1 showing a desire for more information about concept mapping. Two participants peaked at Stage 2 showing concern for how concept mapping might affect their job status. One individual double peaked at Stages 1 and 2 showing the desire for more information while still maintaining personal concerns. The final participant double peaked at Stages 4 and 5 showing concern for the students and the collaboration required with concept mapping. The group profile peaks at Stage 0 with a score of 81. This shows awareness concerns with the innovation, while also indicating that there are other tasks taking priority over concept mapping at this time.

5 Conclusions

The data gathered during this study provided the research team with information to use when planning training for next year. Based upon the Stages of Concern Questionnaire, it is evident that the teachers need more information and exposure to concept mapping. The more this innovation can be tied to things taking priority in the teachers' lives, the better the implementation of concept mapping should go. To do this the team will review other initiatives occurring in the county to tie concept mapping closely with these. If a survey is given to the teachers next year, the research team will not wait until the end of the year because the teachers were so overwhelmed with issues relating to closing out the school year that it may have affected their input.

In planning individual training activities concerning concept mapping, the research team discovered that presentations on concept mapping are not the most effective professional development strategy. Mixing a variety of training strategies throughout the sessions appears to be a positive plan as all of the strategies were identified by different individuals as being the most useful. Several training sessions will include displaying examples of concept maps using pictures, making concept maps with the teachers, and providing participants with pictures, as these were the three most frequently identified strategies by participants for encouraging the use of concept mapping in their classrooms. It is important to remember that participants in this study included the 39 teachers of the 81 present at the training on April 27 that volunteered to be a part of this research. It is likely that these teachers are the ones with the more positive attitudes towards concept mapping. Keeping that in mind, the research team was still encouraged by the fact that the majority of the participants were using concepts maps in their classrooms regularly, and planned to continue doing so in the future.

An idea for extending this study into the next school year is to focus more on the use of concept mapping as an assessment tool with this group of teachers. The concentration this year was on teaching how to use concept maps to plan units of instruction, and as an instructional tool to help children visualize and organize the information they were learning. The research team spent very little time this year talking with participants about using concept maps as assessment tools, so this might be a natural follow-up study to this project. By looking at the concerns identified from the participants' questionnaires and using their survey responses to select the most promising professional de-

velopment strategies, the research team looks forward to an even more productive year of concept mapping with this group of teachers.

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STUDENTS' VIEWS OF TIME AND TENSE REPRESENTED IN CONCEPT MAPS

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Abstract. The uses of verb tenses and its connections with the concept of time represent one of the major difficulties to EFL students who are native speakers of Portuguese. This study addresses the possible relevance of establishing linkages between the concepts of time students already have in their cognitive structure to concepts of verb tense. The author believes that the lack of opportunities granted to students to think about what constitutes time and how this is related to the use of verb tenses may engender many of the problems students have in this area. Students were invited to think about the concept time, and then they discussed it and represented their ideas of time in concept maps. After sharing their meanings expressed in their concept maps about time, they proceeded to the final stage of the experiment: they drew group maps in which they established linkages between/among concepts of time associated to the use of verb tenses. Interactions among students, groups and the teacher were promoted spontaneously during maps presentation and the interaction among groups, students, and teacher.
Key words: Time; verb tenses; usage: relations: meanings; concept map.

1 Introduction

This paper addresses an issue that has concerned teachers of English as a Foreign Language[1] for years, and it is related to the understanding of how EFL students deal with their conceptions of time while they use verb tenses in their English language tasks. The research questions that underlie this study are: How do students understand the concept TIME? and Do students relate the concept TIME to concepts linked to the use of VERB TENSES? In this study, which occurred along the first semester of 2003, 40 college students majoring in languages (Portuguese with a minor in EFL and majors in EFL) and already familiar with the use of concept maps in their Literature and/or English Language classes, answered two questions: What is TIME? Can you represent TIME and its relations to verb tenses in a concept map? The focus here concerns the way students conceptualize time and whether or not they can establish linkages between the use of tenses and the concept(s) of time they have in their cognitive structure expressed here in their concept maps. The framework here has been the theory of meaningful learning and concept mapping (Novak and Gowin, 1984; Novak, 1977) and the ideas of Celce-Murcia & Larsen-Freeman (1983) and Moreira (1994) about language teaching.

The springboard for this article was an experiment carried out in 1990[2] with 82 college students from different fields of study aiming at verifying the ways those students understood concepts of time and their linkages to concepts of verb tenses. Findings from that experiment suggested that most students presented difficulties in establishing linkages between their concepts of time with the use of verb tenses since, for most of them, time was unchangeable in meanings (either perceived as a straight line that went from the past to the present and future, or as a circle containing those verb tenses), so it seemed that they could not think of possibility of choices for the use of verb tenses in relation to time. As in that study research findings suggested that students seldom related the use of verb tenses to the concept(s) of time and that this lack of linkages probably hindered their understanding of meanings underlying the choice of verb tenses, this paper is as an attempt to verify, in 2003, what students think about time and tenses. The 40 students who participated in this 2003 study were all college students of languages (Portuguese/English and EFL), at different levels of the course: twenty students were in their last semester of their EFL course; ten students were taking disciplines at an intermediate level; ten students were in their initial semesters. Except for the students in their last semester of EFL, the others could present their views, explain their drawings/representations, and answer the question about TIME either in Portuguese or in English. However, although they had this choice, most of them responded in English.

[1] English as a Foreign Language, which means that English is taught and learnt in an environment in which it is not needed for communication and interactions in the community. English is seldom used outside the classroom.
[2] "Students's misconceptions of time/relativity in language learning" a paper presented at the Third International Seminar on Misconceptions, 1993,Cornell University, Ithaca, USA, organized by Prof.Dr. J.Novak.

It seems relevant to state that these subjects were enrolled in two different disciplines (twenty in American Literature and twenty in Teacher Training Practice) with the same teacher, who is the author of this paper. Data yielded by answers, representations of these answers, concept maps and their explanations were shared by the whole group (the 40 students), who received copies/transparencies of what their peers had done. Knowledge constructed along the semester encouraged them to further comments, suggestions, concept map constructions that, in turn, would be shared again among the participants.

These students had been informed beforehand that their answers, representations, and explanations would not be graded in a traditional way (with number or letter grades), but that they would be evaluated considering their willingness to learn, expressed through collaboration with peers, participation in brainstorming and discussions, construction of maps until they felt satisfied with what they had expressed in their maps. They were told that they could, if they wished, reconstruct the map and re-write their explanations until they felt confident about them.

2 Methodological remarks and the research issue

After more than two decades of EFL college teaching, the author expected the difficulties students presented with when trying to learn how to us different verb tenses in English. These learning problems just do not emerge from a vacuum[3]: students have brought them along elementary and high school English classes, in which facts and patterns are quite often linked to verb tenses, rather than the choices[4] that underlie the use of one tense [5]instead of another. Usually students have memorized verb patterns (e.g. infinitive form + S for the third person singular of the simple present regular verbs) and facts (e.g. the present tense is used for actions that happen now). Teachers sometimes do not emphasize the role choices play in he actual use of a language, although students enter college with years of practice in the skills of reading, listening, comprehension, and speaking. Students, in many of their schooling experiences, have not been granted opportunities to think about how and/or why [6]language functions the way it does. Students, in general, have not been prepared for learning autonomy[7] , but rather to follow rules established by a teacher who is at center of the teaching event.

The students here often stated that they did not know how to select the verb tense that could more adequately express the point they wanted to make. Ten of these students also informed the teacher that, as native speakers of Portuguese, they thought the most difficult grammar item to master was the use of verb tenses since they considered the grammar of the two languages absolutely different. Whereas 20 students replied that the two languages were not that different at all, and that time could be expressed in both languages quite similarly. However, the biggest hardship for them was that they had never given much thought to the meanings underlying the available choices for the use of tenses to represent, even in their own language, an event within a time framework, although they had memorized facts/rules and patterns related to verb tenses. The twenty students in their last semester of the EFL course complemented what others had said and stated, from their own practice—experiences in the discipline Teacher Training Practice—that the high school students they had observed seemed far from having been encouraged to construct meanings in relation to verb tenses and their connection to concepts of time.

In Portuguese, meanings of verb tenses are quite similar to the ones in English, though tense and time are both translated into Portuguese with the same word: tempo. Students in the 1990 study pointed out that could be a source of problems for Brazilians in EFL courses. Students, in 2003, did not seem at ease either when they were supposed to use the perfective aspect of verbs, though the meaning this verb aspect adds to the utterance in English is much similar to the one in Portuguese. When we say in Portuguese “Tu tens estudado muito ”or “You have studied a lot”, in both languages the meanings attached to the sentences is that you started studying sometime in the past + you are still studying+ it seems that you will continue studying. These are commonalities shared by the two languages.

Notwithstanding, almost 70% of these students reported that they had never thought about these meanings when speaking and writing in Portuguese. For them, thinking about meanings attached to verb tenses constituted something new since, as they had stated, many of their former teachers seemed to believe that teaching a language was teaching about the language.

[3] Ausubel, 1968; Novak, 1977; Novak & Gowin, 1984.
[4] Ellis and Sinclair, 1989.
[5] Celce-Murcia & Larsen-Freeman, 1983.
[6] Gowin, 1981.
[7] Moreira, M.M., 1994.

3 Students' reports on their class observations

The twenty students taking Teacher-Training Practice at UNISINOS (Universidade do Vale do Rio dos Sinos), reported, at the end of their compulsory observations of English classes in public and private schools that:
a) It seemed that neither teachers nor students demonstrated any specific concern with relations that could be established in the choice of an adequate use of verb tenses with particular context of time.
b) Verb tenses are taught as if they have been put away inside different and independent *drawers*.
c) Students seem to be encouraged to believe that facts and patterns are crucial to learn verb tenses.
d) Many teachers seldom deal with verb tenses in their relation to a speaker/narrator and to a reader/listener considering the time of the narrator/speaker and of the reader/listener.

3.1 The teacher researcher asked students about what seemed to be the problem

Student teachers felt frustrated with the teaching situations they had witnessed, and brainstormed about the problems. They discussed the issue with their peers and came up with some possible answers: a) The way to improve students' learning linked to the use of verb tenses seemed to be to emphasize the close relation between what students already knew about the concept time and the use of verb tenses[8] . b) One of the major drawbacks in teaching was that most of the observed teachers followed the textbook. c) Instead of stressing the relevance of thinking and relating what they already knew about time to what they were learning about the use verb tenses, teachers seemed to favor rote learning. d) There were teachers, however, who confessed they had started the school year planning on contextualizing grammar items, specially the use of tenses, but they realized that most students seemed not willing to think and hypothesize[9] about what they were studying in their classes, then they went back to the so-called 'traditional'[10] mode of teaching.

These 40 college students agreed upon what might be one the major causes for this issue concerning the teaching of the use of verb tenses was that teachers usually taught the way they had been taught, while those observed students seemed averse to any changes because they could mean an increase in their workload. They stated that, as teachers-to-be, they would be responsible for changes to improve teaching and learning through thinking and knowledge construction. The teacher-researcher encouraged by these statements, suggested them two tasks related to the use of verb tenses and the concept *time*. Students were highly receptive and willing to participate. They were told that answers and concept maps would integrate their evaluation and that they could repeat the construction of their maps, as well as the answers to the questions until they felt confident about what/how they had done. Students worked in small groups and teacher emphasized cooperation among students. They were encouraged to interact with their peers in the last twenty minutes of a two-hour class period. Those who worked individually would participate in discussions and in the representation of their thoughts in concept maps.

4 Questions and answers

4.1. What is TIME?

The students' answers can be summed up as follows: a) Time is like a line that starts at some point way back in the past and goes on to an unknown point in the future. b) Time can be thought as a line that is marked by events in the past and the present and it ends in a future with unknown events. After discussing their answers, these groups expressed their thoughts and interactions about time in these concept maps, as shown in Figures 1 and 2.

Students shared the map with their peers and explained (and expanded) it as follows: "TIME really runs as a straight line, and once it starts, there is no way it can go back, because it goes and goes from past (yesterday, last year, the time of dinosaurs) to our days (this morning, now), and from today/now to the future (tomorrow, tonight, next month, ten years from now) up to something that for us stands as a huge question mark, representing what lies ahead in the future. Death? Afterlife? Eternity? (Group 1, 2003)".

[8]Novak &Gowin, 1984.
[9]Gass & Selinker, 2001.
[10]Traditional teaching here means having the teacher at the very center of the teaching/learning event as the controller of everything that he/she has planned to happen inside the classroom (according to Novak, 1998).

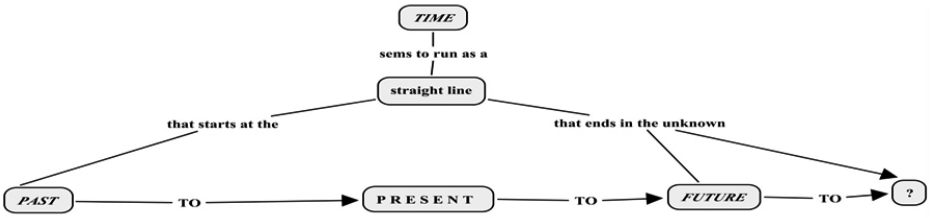


Figure 1. The forwardness of the line of TIME leading to unknown

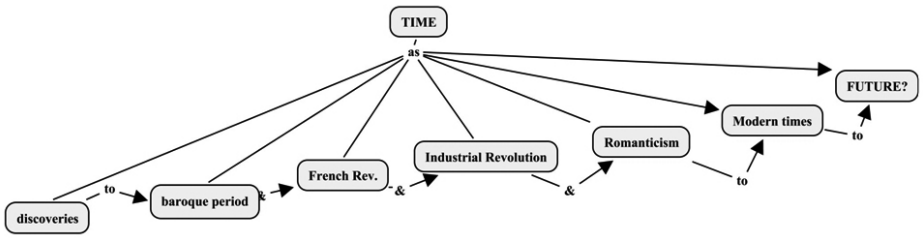


Figure 2. TIME marked by events in history with an unknown future

Students explained their representation of time in this map to their classmates. "TIME is puzzling, and we thought time in terms of historical and/or literary events and although we know that there were many events before the great discoveries (15th and 16th centuries) we decided not to go much further on into the past. We represented time as happenings from the periods of discoveries, the baroque in literature and history, the French Revolution, the Industrial Revolution that modified human life; Romanticism brought new life styles that led to new ways of expressing feelings and describing the world. Well, Modern Times historically has started in the past but we infer their relation to NOW. And the future belongs to God, our actions, and/ or to fate, since we do not know what will happen there (Group 2, 2003)".

c) Time is a line that goes round and moves from the past to the future, but it continues into something we call "infinite", and then it starts all over again in its encounter with TIME, and the circle never ends. This group represented time as shown in Figure 3:

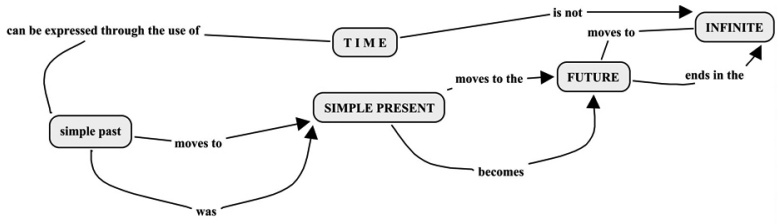


Figure 3. A concept map for Time as a line moving from simple past to simple past and to the future

In their explanation for their expression what they thought and felt about time, they stressed that time never ends whereas human beings do, although their life cycle might continues in the memories of those who have loved them. The "simple past tense" can express a period that is over and done with, though time moves and becomes now, as it moves on to the "simple present tense". Then, the simple present, with the passing of time, becomes the future. The future moves on to the infinite where it ends. We expressed in the map the infiniteness of time when the circle is closed with the never-ending repetition of these stances with generations and generations of human beings. For us, however, TIME IS NOT INFINITE (Group 3, 2003)".

d) TIME comprises a flow of moments in the past, present, and future.
This group shared with peers the concept map drawn to sum up their thoughts about TIME, as shown in Figure 4.

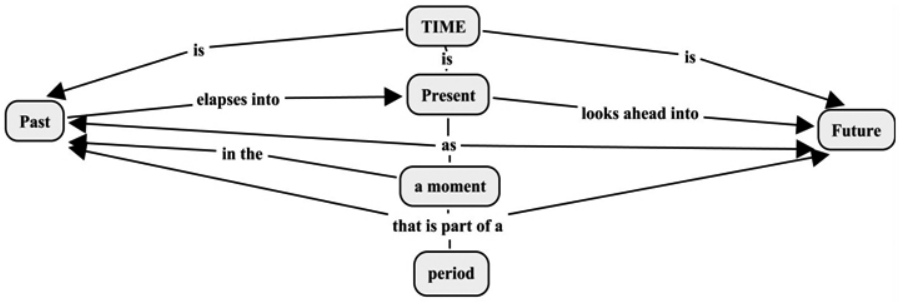


Figure 4. A representation of Time as marked moments and periods in the past, present, and future

The group explained their standpoints as shown in Figure 4. "We did not make explicit the most important concept—TIME—because we thought this would not be necessary since the map was part of our answer linked to our ideas about it. The concept time was positioned at the very top of our map: TIME is the concept that comprises all the others. We perceive the different instances of time, that is, past, present and future, as a moment, or a sequence of moments, that looks back into the past, as the present will surely become the past, while the past elapses into the present, while the present becomes/looks ahead into the future. Time is quite complex because it encompasses looking back and forward from a given point—though we have not let this clear in the map. But examining it now (a moment in the present, which right after having it said or written, becomes part of the near past), we can notice that the point in time in which we stand, while looking at moment that forms a period of time, is relative to back or for movements. So, if we are in a moment in the past, the present is the future; if we are in a moment of the present, this single moment becomes past in less than a fraction of second. We agree with what we have represented in the map, though now, at the time we are explaining it, we are able to perceive important things we have left out of it. The map we have in our minds at this period, which is made of moments, is different and much more comprehensive than the ones when we have drawn the map (Group 4, 2003)".

e) TIME is an idea that encompasses past, present and future. Students in this group used their concept map—shown in Figure 5—to justify and elaborate a bit more on their answer.

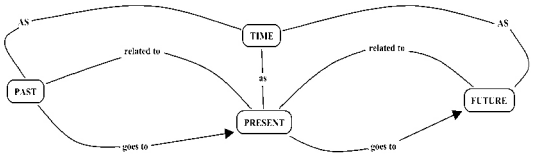


Figure 5. TIME as an idea that encompasses past, present, and future

"As you may notice, our map reminds us —a bit roughly—of a pair of spectacles. Actually there has been another group before our presentation that did something quite similar although nobody has been aware of this resemblance. We realized this when we thought the map could be adequate enough to represent our positions and thoughts about TIME. Then we started thinking that, though not consciously, we look at TIME through spectacles of past, present and future, which are interrelated. TIME is present, past, and future depending on the way we look at it, think about it, feel it, and remember it. The present is at the nose bridge of the goggles because we, usually, see or look at things/events from the perspective of the present. This, however, might shift, as we get older so that the past might be in this position later in life. Thus, Einstein was correct with his relativity stuff! (Group 5, 2003)"

f) TIME is life. " It is the sequence of events that have marked my life up to now and that will continue to do it in the future. I did the map by myself because I could not attend last class, but I showed it to my peers and they offered suggestions that were quite enriching."

This is an individual answer, though some groups have interacted with this student about the point he/she was trying to make. After brainstorming and argumentation, he/she has slightly modified it. Here is the concept map, shown in Figure 6.

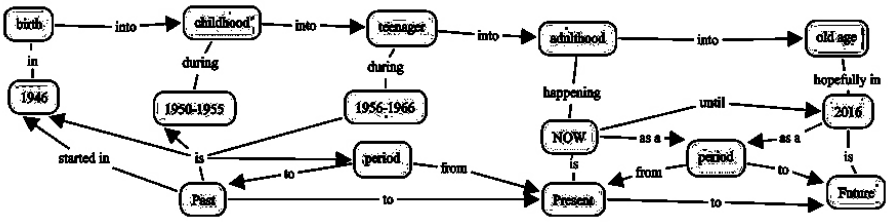


Figure 6. A representation of TIME as moments in life

The student explains his/her construction:

"In this map the most important concepts are at the very bottom: I should have rotated it, but I have not. I will re-do it and will include at the top the concept TIME, which is so embedded in the ideas presented here that I have forgot to do it, but I have it in my drafts. LIFE should have been also included right below TIME, and the linking word would be "as my"(TIME as my LIFE). Everything is connected and there is interaction because past, present and future interact as each one of hem leads to the other, and as each one of them has effects on the different periods of time in my life. Because I am a bit afraid of what awaits for me in the future, my present/past has been affected. We cannot go back in TIME, but we can relive periods of our past as we can pre-live future moments with our imagination. TIME moves as we move and, as we look at it changes as we move from now to yesterday or tomorrow (Student C., 2003)".

g) Time can be defined as cycles in overlapping circles. Again this answer comes from an individual student who used the concept map shown in Figure 7 to explain his/ her way to conceptualize time.

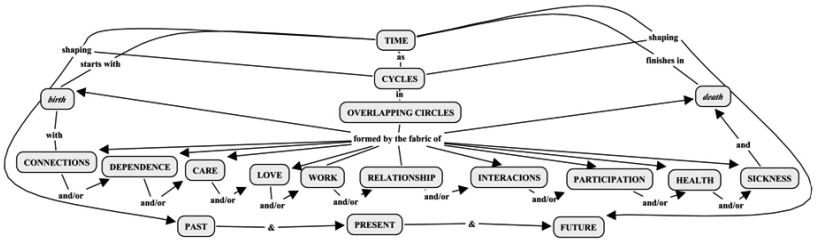


Figure 7. TIME as cycles similar to overlapping circles starting with birth and ending in death

He/she explained the map as follows. "For me, TIME has many cycles that shape past, present, and future. The cycles overlap, meaning that one cycle has bits of the other cycle(s), and they weave the fabric of life, with feelings, emotions, and physical/emotional states. TIME starts at the birth of a person and ends at his/her death. Time weaves everything together (Student D. 2003)".

4.2 Can you represent TIME and VERB TENSES in a concept map?

The students, after having participated in the presentation of maps with a discussion on the elements of TIME, answered this question by presenting and explaining a concept map. The students worked in groups and they shared ideas and meanings about all maps presented. The concept maps shown here were selected by the students as representatives of various ways of looking at TIME and VERB TENSES. The ones in Figures 8, 9 and 10 were collective maps, and students considered them the most complete ones, although they stated that, based on these maps, they would be able to come up with new interrelated concepts and with new The linkages/propositions. Maps in Figures 8, 9 and 10 were drawn collectively after meaning negotiation and sharing of these meanings among the various groups that included the 40 students participating in this study. Actually, Figures 8 and 9 present concept maps that, according to the students, complete each other, not by super-posing them but by using them side by side, because there are concepts in Figure 8 that expand concepts in Figure 9, and vice-versa.

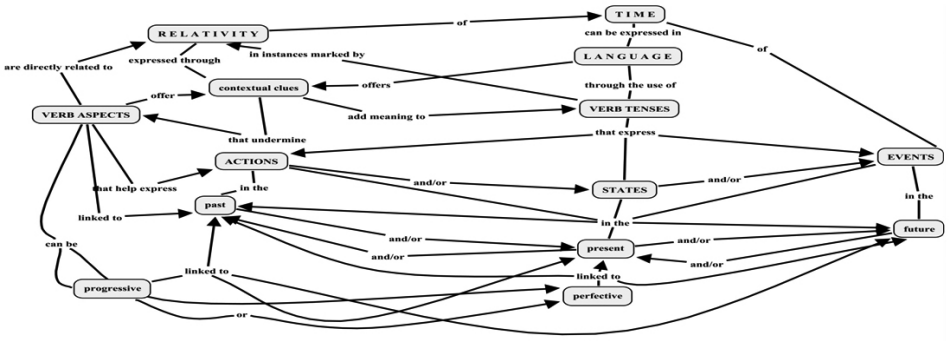
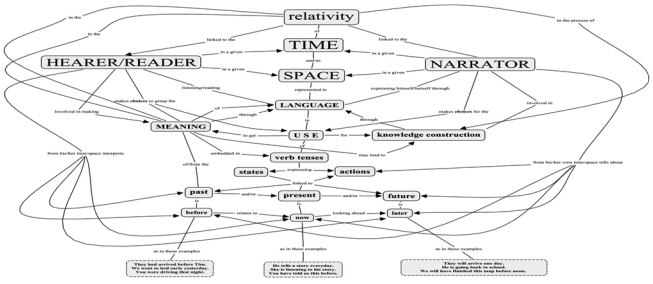


Figure 8. Relativity and time as expressed in verb tenses and aspects

Students explained these two maps emphasizing their many points in common and that they kind of complemented one another. " In the map—Figure 8—we came up with the concept TIME that is comprised in RELATIVITY since the use of verb tenses/aspects depends on contextual clues that add meanings to what we want to express when we use a given tense. TIME and its RELATIVITY are expressed through language and they are directly correlated to the use of the progressive and perfective aspects of verbs, as well as any tense. It seems quite impossible for a speaker/writer/reader/listener not to establish linkages between TIME/RELATIVITY and the USE OF TENSES (Representatives of the 40 students who constructed collaboratively this map, 2003)".

" The second map (Figure 9) is quite similar to the previous one drawn last week, although it adds the concept SPACE to the picture, together with an explicit stress on MEANING, DOING (in the previous one we used the concept name ACTIONS), and on the concept FORESIGHT linked to the future. RELATIVITY underlies SPACE the same way TIME implies SPACE and RELATIVITY, whereas CONTEXT is very close to SPACE. MEANING is crucial since it can provide additional clues to CONTEXT. We repeat that the awareness that there is relativity in TIME has helped us in perceiving it as something that can move in many directions. As one of the groups explained about the map that reminded us of goggles, we can say that by realizing this might help us teach our own students in a more meaningful way. Furthermore, these interactions among groups for sharing maps and ideas have been very enriching and we will use concept maps and their explanations with our students. (Representatives of the 40 students who constructed collaboratively this map, 2003)."

4.3 Students summed up their ideas on TIME and VERB TENSES in a CONCEPT MAP



This map tries to look at concepts students have used in their other maps taking into account all the maps, but mostly the last two ones, shown in Figures 10 and 11. For the first time they have resort to examples (in blue at the bottom of the map) attempting at clarifying what they have understood as BEFORE, NOW, LATER. " This map represents the thoughts constructed this semester about this important language issue: the use of tenses in English. We have also thought about our own language and we have "discovered" meanings behind the use of each tense/aspect, and we might say that we have learned a lot about the use of tenses in Portuguese after school, when we have had many a-ha experiences[11] for being suddenly aware of the linkages between TIME and the USE OF TENSES/aspects. We have had conversations about the way we could help other EFL students understand meanings embedded in tenses because

of the different meanings of time depending on the context of the participants in an interaction. What we mean to say is that TIME depends on the eyes of the beholder (Representatives of the 40 students who constructed collaboratively this map, 2003)".

5 Concluding remarks

The initial questions about the reasons why students have problems concerning the use of verb tenses in general, and of the perfective aspects of tenses in particular, seem to have as possible answers, according to what was expressed by them in opinions, answers and drawings, follows:

a. Students seem to be led by teachers to memorization of rules without any connection to what they already have in their cognitive structure. That is, verbs are taught through fixed sets of rules with examples and applied to an artificially designed use, in which the element 'choice' is not considered.

b. Verbs are studied without any link to time-space, so that facts and patterns of verb tenses are completely outside a framework of context, content, narrator/writer, listener/reader, author. c. In general, teachers and students see time as a line that moves forwards so that they have difficulties understanding the perfective aspects.

d. Student's difficulties in associating TIME with the USE OF TENSES may determine most of their problems concerning their exercise of choice and autonomy linked to verb tenses in a real situation.

e. EFL textbooks seldom aim at constructing knowledge based on concepts and besides many teachers feel safer when using a textbook[12] .

f. Students seemed to have learned the use of verb tenses more meaningfully through the use of concept maps.

These forty students seemed motivated to construct their concept maps throughout the study. Cognitively speaking, their previous knowledge seemed to have improved their ability to handle grammar items—verb tenses more specifically here—both as students and teachers-to-be. The awareness of their autonomy in learning how to learn seemed to have been built with the help of concept maps based on the knowledge that resulted from peer interaction, sharing of meanings, group cooperation, brainstorming, collective drawing of maps, as well as classroom observation. Working collaboratively with their peers and the opportunity to draw the maps until they felt satisfied with the way they had represented the thoughts and feelings they wanted to express, as well as the freedom from the dichotomy "right"/"wrong", might have granted them autonomy for making their own choices after thinking, individually and collaboratively, and for sharing and negotiating meanings.

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[11] Richards, 1996.

[12] The comments on textbooks come from observations but they do not mean to state that textbooks are bad. In fact, most of them are quite good and some teachers realy know how to use them, creating opportunities for meaningful learning.

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Viña del Mar, Chile, 2010

STRUCTURAL ANALYSIS OF CONCEPT MAPS TO EVALUATE THE STUDENTS' PROFICIENCY AS MAPPERS

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Abstract. Mappers' proficiency on concept mapping is essential to achieve all promised rewards we want to find when using Cmaps to represent and share knowledge. Training sessions for beginners should be explored to overcome the naive use of this technique. This work proposes a quantitative structural analysis of the Cmap fine morphology to determine the skill level of students during the ACH 0011 Natural Science course. Sixty nine Cmaps were analyzed and the results are presented by using descriptive statistic and hierarchical cluster analysis (multivariate exploratory approach). We characterized 5 clusters containing Cmaps with distinguishable features, and the Cmaps made by beginners (class 1) were quite different from those prepared by these students in class 15. Among the 8 parameters used to describe the Cmap fine morphology, propositional density, initial concepts with multiple propositions, and final concepts with multiple propositions can be considered as potential "fingerprints" to monitor the students' expertise on concept mapping, since in our case, they increased when the students' experience with concept mapping increases.

1 Introduction

Concept maps (Cmaps) were proposed by Novak and colleagues during the early 1970s. They can be defined as a set of concepts embedded into a propositional framework. Concept mapping plays a key role as a tool to represent knowledge held by a learner, and also the structure of knowledge in any subject field (Novak, 2010).

In spite of being a well-established technique, widely used for educational and corporate purposes with a broad range of goals (Coffey et al, 2004; Coffey, 2006; Fourie & Westhuizen, 2008; Kyrö & Niskanen, 2008; Novak, 2010; Torres & Marriott, 2009), some obstacles still need to be overcome. The apparent ease of production of Cmaps is tempting to beginners and explains their popularity. However, naive use of concept mapping may cause few (or none!) of the expected benefits, and such experiences may be playful and funny at best (Correia, Infante-Malachias & Godoy, 2008). Some works in the literature show that many of the difficulties observed with the use of Cmaps derive at least in part from the inappropriate use of the technique, inadequate training for users and trainers, and a general failure to recognize the importance of the tool's theoretical foundations (Correia, Infante-Malachias & Godoy, 2008; Cañas & Novak, 2006).

Cmaps can be analyzed in different ways for different purposes. Figure 1 presents our understanding about three complimentary evaluations that can be useful to capture all information available in Cmaps. The concepts in Figure 1 are organized as follows: Cmap key parts (corner A), Cmap analyses using a semantic approach (corner B), Cmap structural analysis (corner C), and considerations about the mappers' proficiency (corner D).

This framework expresses our beliefs about the importance of training mappers to make good Cmaps. Training is essential to ensure the experience of the rewards of concept mapping, and purposeful activities should be designed for this goal.

The aim of this work is to examine the relationships between network morphology of Cmaps (Fig. 1, corner C) and the mappers' experience (Figure 1, corner D). We hypothesize that the advancement of mappers' expertise will increase the complexity of the Cmap structure. Therefore, an 8-paratemeter set was devised to develop a quantitative appreciation of the structural features of Cmaps.

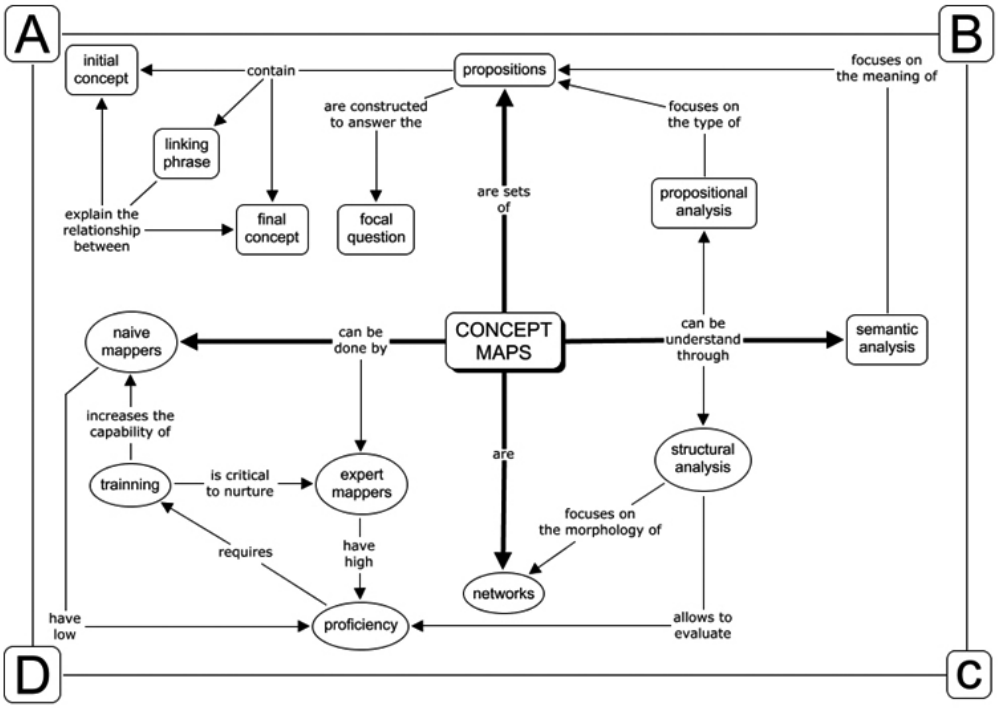


Figure 1. The relationship among the Cmap key parts (A), analyses using a semantic (B) and structural (C) approaches, and the mappers' proficiency (D). The core idea of this work involves the links between structural analysis (B) and mappers' proficiency (D)

2 Research procedures

2.1 Setting and data collection

The Cmaps (n=69) considered in this work were obtained during the ACH 0011 Natural Sciences course, which is offered for all first-year students at Escola de Artes, Ciências e Humanidades (School of Arts, Science and Humanities at São Paulo University). The main goal of this course is to provide a comprehensive view of the impact caused by scientific and technological development in our society (Correia et al, 2010; Santos, 2007). Sixty students from four different undergraduate courses were grouped in one classroom, for two-hour weekly classes over a period of fifteen weeks. Considering the course's introductory scope and the diverse audience, the challenge to meet students' expectations required innovative methodological strategies.

Students were introduced to concept mapping and trained to elaborate both manuscript and digital Cmaps using the Cmaptools software at the beginning of the ACH 0011 course. Half-structured Cmaps (HSCmaps), expanded collaborative learning (ECL) and propositional clarity table (PCT) are innovative approaches that enhanced the training session (classes 1-4), as described in the literature (Correia, Infante-Malachias, & Godoy, 2008). Two different sets of Cmaps were considered in this work: collaborative Cmaps (n=14) obtained during class 1 (naive mappers), and individual Cmaps (n=55) obtained during the class 15 (experienced mappers). Table 1 summarizes the most relevant information about the conditions used for asking these Cmaps. It should be highlighted that the subject in both cases (class 1 and 15) were familiar to the students, and that the main difference between them is the students' expertise on concept mapping.

	Class 1 Cmaps	Class 15 Cmaps
Number of collected Cmaps	14	55
Authorship	Collaborative, 2- or 3-student groups	Individual
Number of concepts	11-14	9
Focal question	*Why is so hard to get a place in the undergraduate courses offered by USP?*	*How does bioethics regulate the relationship between science and society?*
Students' familiarity about the subject	High	High
Students' proficiency on concept mapping	Naive	High

Table 1. Comparison about the Cmaps considered in this work

2.2 Structural analysis of HSCmaps

Among several works dealing with structural analysis of Cmaps (BouJaoude & Attieh, 2008; Gerstner & Bogner, 2009; Kinchin & Alias, 2005), there is a outstanding paper published 10 years ago (Kinchin, Hay & Adams, 2000). The authors proposed a qualitative approach to analyze the gross morphology of Cmaps. The main patterns (spoke, chain, and net structure) were related to the students' understanding about the mapped and their learning preferences. This qualitative approach inspired us to develop a quantitative description of the Cmap networks. We developed a set of 8 parameters that capture all structural features of Cmaps. These parameters are based on the fundamental building blocks J, K, and L shown in Figure 2.

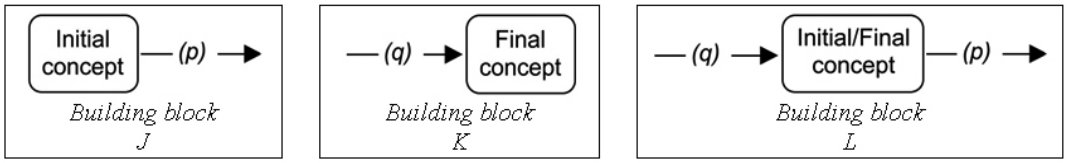


Figure 2. Fundamental building blocks (J, K, and L) of Cmaps' network considered for structural analysis

The parameters for structural analysis are described from the variables represented by J, K, L, p and q letters, which are found in the proposed fundamental building blocks (Figure 2). Table 2 presents the 8 parameters devised for the quantitative structural analysis, the notation adopted throughout this work, and the computation of each parameter.

- J: initial concept structure, characterized by a concept with arrow(s) pointing to another concept(s).
- K: final concept structure, characterized by a concept with arrow(s) pointing to it.
- L: initial and final concept structure, characterized by a concept with arrow(s) pointing to another concept(s) and arrow(s) pointing to it.
- p: number of propositions formed from an initial concept.
- q: number of propositions finishing in a final concept.

	Parameter for structural analysis		Correspondence with structural building blocks	Computation
	Description	Notation		
	Concepts (boxes)	C	-	-
	Propositions (arrows)	P	-	-
1	Propositional density	PD	-	PD=C/P
2	Only initial concepts	OIC	J	OIC=J/C
3	Only final concepts	OFC	K	OFC=K/C
4	Initial/final concepts	IFC	L	IFC=L/C
5	Initial concepts	IC	J+L	IC=(J+L)/C
6	Initial concepts with multiple propositions	MIC	Jm+Lm=J+L, when (p≥2)	MIC=(Jm+Km)/C
7	Final concepts	FC	K+L	FC=(K+L)/C
8	Final concepts with multiple propositions	MFC	Km+Lm=K+L, when (q≥2)	MFC=(Km+Lm)/C

Table 2. Parameters for the quantitative structural analysis of Cmaps

Propositional density (PD) is the exception to this rule, and it is defined as the ratio between the number of propositions (P) and concepts (C).

2.3 Data analysis

2.3.1 Descriptive statistics and t-test

Box-plot graphs were used to show the statistical parameters (average, median, lower quartile, upper quartile, sample minimum, and sample maximum) obtained to describe each variable considered in our analysis. These graphs allow checking the central tendency, the symmetry, and the dispersion of a data set at a glance (Cohen & Lea, 2004).

A comparison of the averages for each variable was made by using t-test. It usually determines whether two means are significantly different from each other, and allowed to compare the values that describe Cmaps obtained during classes 1 and 15. The larger the t value of the test, the more likely the test is statistically significant and the compared averages are different (Cramer & Howitt, 2004).

2.3.2 Cluster analysis: multivariate statistics

A data matrix X(69,3) containing only selected parameters (PD, MIC, and FMC) was used to carry out hierarchical cluster analysis (HCA). HCA is an exploratory statistical procedure to classify class 1 and class 15 Cmaps into groups according to their similarities (Kaufman & Rousseeuw, 2005). Statistica 8 (StatSoft, Tulsa, OK, USA) was the software chosen to run this analysis. The graphical output of HCA (dendrogram) will be used to discuss the results in the next section.

3 Results and discussion

3.1 Descriptive statistics: comparing the results for class-1 and class-15 Cmaps

The 69 Cmaps were analyzed considering the 8-parameter set indicated in Table 2. Average and standard deviation for the subsets of Cmaps obtained in class 1 (n=14, collaborative) and class 15 (n=55, individual) were presented for comparative purposes (Table 3).

Parameter	Class-1 Collaborative Cmaps (n=14)	Class-15 Individual Cmaps (n=55)	Calculated t	Are the averages significantly different?[a]
PD	1.0±0.2	1.7±0.4	6.32	Yes
OIC	1.8±1.4	1.4±1.0	1.23	No
OFC	2.8±1.2	2.3±1.3	1.30	No
IFC	5.3±2.0	6.4±1.7	2.09	No
IC	7.1±1.1	7.7±1.4	1.49	No
MIC	2.1±1.3	4.9±1.6	6.05	Yes
FC	8.1±1.4	8.6±1.1	1.43	No
MFC	1.6±1.3	5.3±1.7	7.58	Yes

[a]Critical value: t(p=0.0005, df=∞) = 3.29.

Table 3. Averages for the parameters considered during the structural analysis of Cmaps and the results obtained by using t-test

The average comparison using t-test allowed the identification of 5 parameters that did not change significantly. The calculated t for OIC (t=1.23), OFC (t=1.30), IFC (t=2.09), IC (t=1.49), and FC (t=1.43) was lower than the critical value (3.29). Therefore, the increase of the students' experience with concept mapping did not affect them. On the other hand, the parameters PD (t=6.32), MIC (t=6.05), and MFC (t=7.58) showed calculated t values far above than the critical value (3.29). Moreover, the averages for PD, MIC, and MFC were higher for class 15 than class 1 Cmaps. It was possible to identify these parameters as potential "fingerprints" to monitor the students' proficiency on concept

mapping, since in our case, they increased when the students' experience with concept mapping increases. For this reason, the following discussions consider only propositional density (PD), initial concepts with multiple propositions (MIC), and multiple final concepts with multiple propositions (MFC).

3.2 Box-plots for the devised categories

Figure 3 presents the box-plots obtained for the selected parameters (PD, MIC, and FMC) after comparing the averages for class 1 and class 15 Cmaps. The average (Av) and the median (Me) of propositional density (PD) were Av=1.0±0.2/Me=1.0 and Av=1.7±0.4/Me=1.7, for class-1 and class-15 Cmaps, respectively. This noteworthy increase indicated that trained students can include more propositions during the set up of concept maps than beginners. This fact may be related to the new way of expression that is imposed by concept mapping. Students need to express his/her ideas, by using concise, clear, and precise elements (linking phrase, initial and final concepts) to construct meaning. Readers and writers may "unlearn" the manner they usually elaborate their oral/written discourses to work with a more interconnected net of keywords (concepts) and brief explanations (linking phrases).

The transition from linear thinking and understanding (texts) towards a systemic perspective (Cmaps) was confirmed by the increase of average and median for MIC and MFC (class 1: Av=0.2±0.1/Me=0.2; class 15: Av=0.5 ±0.2/Me=0.6 for both). Moreover, MIC and MFC may indicate the occurrence of progressive differentiation (MIC) and integrative reconciliation (MFC) during the Cmap elaboration. As these processes are related to meaningful learning (Ausubel, 2000), we can assume that MIC and MFC may be useful parameters to verify students' options into the root-meaningful learning continuum.

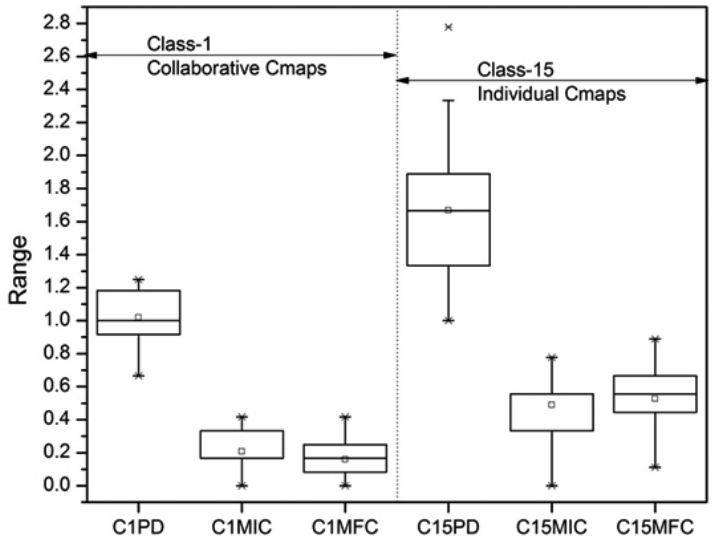


Figure 3. Box-plot obtained for selected parameters of the structural analysis (PD, MIC, and MFC) to highlight the differences between class-1 and class-15 Cmaps

3.3 Finding patterns through cluster analysis

Hierarchical cluster analysis (HCA) was used as a multivariate exploratory analysis (Kaufman & Rousseeuw, 2005). A subset of the data obtained through structural analysis was organized into as a matrix X(69,3). Only PD, MIC, and MFC were considered for clustering purposes due to the results shown in Table 3.

Several methods for measuring distances were tested in order to achieve the most meaningful clusters, considering our expertise on concept mapping. Distances between objects (Cmaps) were measured using single, complete, and Manhattan (or City-Block) methods. Distances between clusters were measured using Euclidean and Ward's methods. The dendrogram presented in Figure 4 was obtained using Manhattan and Ward's methods for measuring

distances between object and clusters, respectively. An arbitrary value corresponding to 15% of de maximum distance between 2 objects (Cmaps) was chosen to define the clusters to be compared. The dotted line in Figure 4 helps to identify 5 clusters (I-V).

Despite the descriptive parameters presented in Table 3 for all Cmaps (n=69), the average for the selected variables (PD, MIC, and MFC) was calculated for characterizing each cluster. The differences between clusters can be discussed from the data presented in Table 4. The use of black dots was an option to make easier to compare the distinguishable features of each cluster. In spite of all quantitative manipulations of the data, the qualitative approach prevails when HCA is used. Therefore, the information in Table 4 is presented in a friendly graphical manner.

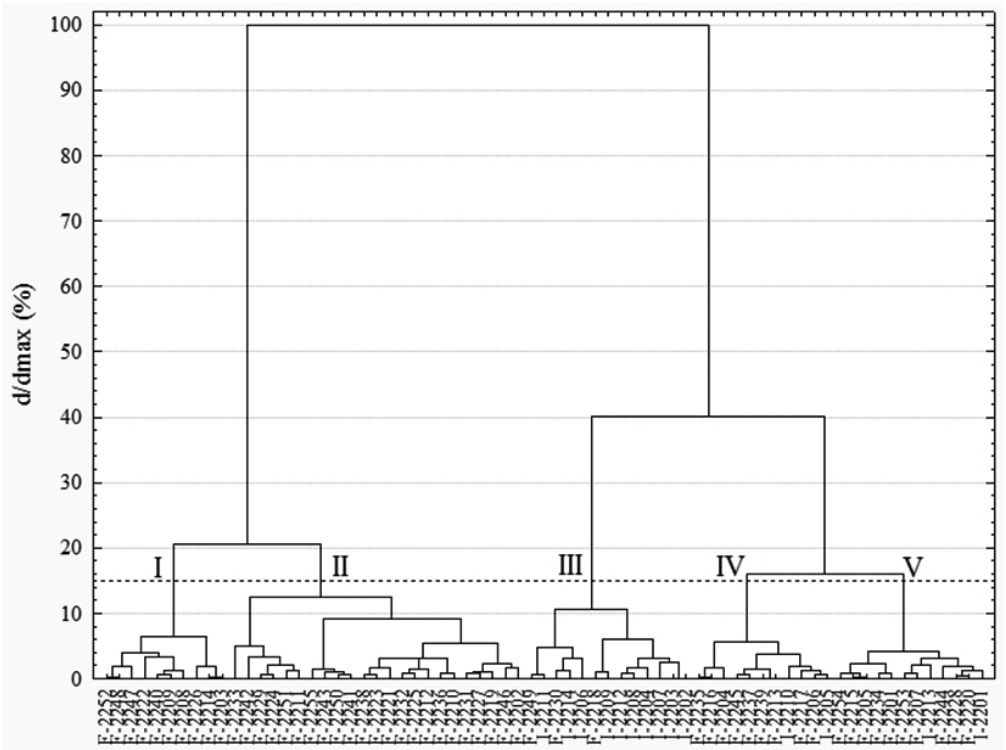


Figure 4. Dendrogram obtained by HCA considering the matrix X(69,3). Selected parameters for running HCA: Manhattan (or City Block) distance to measure between CMaps distance; Ward distance to measure between clusters distance. An arbitrary value of 15% of the maximum distance (dmax) was selected to characterize the clusters (I-V). Notation in the dendrogram: F-type Cmaps are from class 15 (n=55); I-type Cmaps are from class 1 (n=14)

	Cluster ID	**I**	**II**	**III**	**IV**	**V**
	# of CMs	*10*	*23*	*13*	*11*	*12*
Parameters for structural analysis	*PD*[a]	●●●	●●●●	●	●●	●●
	MIC[a]	●●●	●●●●	●	●●	●●
	MFC[a]	●●●	●●●●	●	●●	●●
	IFC	●●	●●●●	●●	●●●	●
	IC	●●	●●●●	●●	●●●	●
	FC	●●	●●●●	●●	●●●	●
	OIC	●●●	●	●●●	●●	●●●●
	OFC	●●●	●	●●●	●●	●●●●

[a]Parameters considering for clustering purposes.

Table 4. Differences between clusters explained by the parameters used for structural analysis. The number of black dots indicates the relative average magnitude for each cluster. Highest values (••••), lowest values (•), intermediate values (••) or (•••)

The highest average values (••••) for PD, MIC, and MFC described cluster II, which contains the best Cmaps in structural terms. It should be highlighted that cluster II presents only Cmaps made by experienced students (class 15). The opposite could be verified for cluster III, which contains the lowest average values (•) for PD, MIC, and MFC. This cluster concentrates the majority of the Cmaps made by naïve mappers.

Intermediate values (••/•••) were useful to characterize clusters I (••• for PD, MIC, and MFC), IV, and V (•• for PD, MIC, and MFC). Cluster I is similar to cluster II and it also contains only Cmaps from class 15. The structural qualities found in Cmaps classified in clusters I and II are only achieved by well-trained mappers. On the other hand, the properties found in Cmaps assigned in cluster III characterize beginners with no or little experience in concept mapping. Clusters IV and V were mainly formed by Cmaps from class 15 that are not so good in comparison to their counterparts classified in clusters I and II. Four Cmaps from class 1 were allocated in clusters IV and V, suggesting they should be better than the pattern found for the majority of the other Cmaps prepared by the beginners.

A summary of the clusters' description from the selected parameters (PD, MIC, and MFC) makes clear the dependency between mappers' proficiency and the Cmap structure.

- Highest values (••••) for PD, MIC, and MFC: cluster II, which contains the best class 15 Cmaps.
- Lowest values (•) for PD, MIC, and MFC: cluster III, which contains the majority of class 1 Cmaps.
- Intermediate values (•••) for PD, MIC, and MFC: cluster I, which is similar to cluster II and contains only class 15 Cmaps.
- Intermediate values (••) for PD, MIC, and MFC: clusters IV and V, which contains ordinary class 15 Cmaps and 4 class 1 Cmaps.

4 Summary

Mappers' proficiency on concept mapping is critical to achieve all promised rewards we hope to find when using Cmaps to represent and share knowledge. Training sessions for beginner mappers should be explored to overcome the naïve use of this technique. This work showed the relationship between mappers' proficiency and the structure of the Cmaps. The quantitative structural analysis was proposed to describe the fine Cmap morphology. We found that propositional density (PD), initial concepts with multiple propositions (MIC), and final concepts with multiple propositions (MFC) can be use to estimate the proficiency level of the mappers. The increase of these parameters indicates a better understanding about how to set up a concept map. Despite this work being explored Cmaps about science teaching, we believe that the quantitative structural analysis has a wide range of applications, including both educational and corporative uses.

5 Acknowledgements

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THE ADDED VALUE OF COMMUNICATION IN A CSCL-SCENARIO COMPARED TO JUST HAVING ACCESS TO THE PARTNERS' KNOWLEDGE AND INFORMATION

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Abstract. According to Wegner's theory of transactive memory system, in order to be able to collaborate effectively group members should both know which member knows what and communicate with each other. Sometimes, however, communication could also deteriorate group performance. Therefore, in this paper, a study is presented investigating whether it is sufficient for computer-supported problem solving to have direct access to the representation of externalized knowledge and information of the other group members by means of digital concept maps or whether communication with the other group members is also needed. In an empirical study (N = 81) triads with spatially distributed group members, that both had access to the externalized knowledge and information of the others and could communicate with each other, were compared to a condition in which the participants just had access to the knowledge and information of the others without the possibility to communicate. Results show that it is not sufficient just to have access to the knowledge and its underlying information of the others: Communication resulted in fewer mistakes in the problem-solving process, a superior performance in a complex problem-solving task, and communicating group members felt less stressed during problem solving compared to the condition without communication.

1 Theoretical Background

Research over several decades now has addressed the question whether groups perform better than individuals. The findings suggest that this is highly dependent on the task, its context (e.g., timely requirements), the individual skills as well as the medium or media applied to accomplish the task (e.g., Benbunan-Fich & Hiltz, 1999; Propp, 2003). For example, research has shown that groups perform better than individuals when both the group members have unshared task-relevant knowledge, that is, task-relevant aspects the other group members do not know yet, and they are willing and able to integrate this knowledge (e.g., Hollingshead, 2001). However, research on information sampling has consistently shown that groups are often biased to focus on knowledge that is shared by all members compared to unshared knowledge (e.g., Stasser & Titus, 1985). According to Franz and Larson (2002) group members are more likely to share their unshared knowledge if the expertise of each group member is known among each other. This points to the importance of communication within groups.

The described research implicates that groups work successfully if the group members share their unshared information, that is, if every group member knows all the task-relevant information aspects. This leads to the question whether a group member who knows all (shared and unshared) task-relevant knowledge elements still needs the others for solving the task or whether s/he is able to solve the task by herself/himself. However, learners can become cognitively overloaded if they have to handle too much information: Information beyond a specific high amount exceeds the individual's processing capacity resulting in performance decline (e.g., Eppler & Mengis, 2004). With increasing information load, it becomes increasingly difficult for example to identify and select relevant information. Information overload, thus, leads to more errors (Sparrow, 1999) and less accurate decisions (e.g., Malhotra, 1982).

This is in line with Wegner's (1986) theory of transactive memory system. According to Wegner, in a group it is not necessary to share all task-relevant information, but it is enough to know who knows what. Moreover, knowing who the experts in a group are improves group memory performance. He defined a transactive memory system as "a set of individual memory systems in combination with the communication that takes place between individuals" (Wegner, 1986, p. 186). Accordingly, communication between the group members plays an important role for the functioning of transactive memory systems because it supports, for example, getting to know who the experts are in a group (Wegner, 1986).

However, communication is not always helpful: For example, brainstorming research found that communication during memory retrieval can produce interferences with individual retrieval strategies (e.g., Diehl & Stroebe, 1991). According to Pavitt (2003) communication, especially with growing group size, does not result in optimal information sampling. Communication therefore seems to be at times helpful or even necessary (e.g., in order to exchange unshared task-relevant information), but it could also increase cognitive demands in a way that affects performance negatively (e.g., Dillenbourg & Bétrancourt, 2006): Following Dillenbourg and Bétrancourt, collaboration – and therefore also communication – can decrease individual cognitive load if some degree of division of labour is established. However, they also constituted that collaboration also creates additional cognitive demands, for example, due to the need to express one's own thoughts or to try to understand each other.

To sum up, groups perform better than individuals if both they have to consider and do consider task-relevant unshared information while solving a task. This group advantage is caused by the distribution of the task-relevant knowledge among the group members that reduces individual cognitive load. As described, however, communication on the one hand is important for information exchange during group problem solving, but on the other hand, it may also increase an individual group member's cognitive load. This leads to the following assumptions: (1) Is communication between learners in a typical computer-supported collaborative learning (CSCL) situation, in which the spatially distributed group members have to solve problems together by means of computer support, a hindrance to their collaboration? In this case, it would have to be expected that individuals who have been provided with all task-relevant (shared and unshared) knowledge elements not leading to cognitive overload, should perform the task as effectively or even more effectively than groups, because they do not have to communicate. The question is whether it is possible to provide individuals with all task-relevant knowledge elements without causing cognitive overload. There is a great deal of empirical evidence that especially visualizations may reduce cognitive load (e.g., Sweller & Chandler, 1994) and serve as a basis for externalized cognition (e.g., Scaife & Rogers, 1996). Therefore, it can be assumed that access to visualizations of the externalized knowledge of other group members could be an efficient way for individuals to solve problems as effectively or even more effectively as the groups with unshared knowledge, which we have described above, on the assumption, of course, that communication does indeed decrease group performance. An example of such corresponding visualization is the knowledge and information awareness tool by Engelmann and colleagues (e.g., Engelmann, Tergan, & Hesse, 2010; Engelmann & Hesse, 2010). They defined knowledge and information awareness as being informed with regard to both the knowledge and its underlying information of the collaboration partners. A typical tool for fostering knowledge and information awareness is a computer-supported representation of externalized knowledge structures and the underlying information of the partners by means of digital concept maps (e.g., Engelmann et al., 2010; Engelmann & Hesse, 2010). Having access to this kind of tool, the individual does not have to keep all information in mind. If members want to know something, they can easily check it out in the collaborators' maps. This is accordant with the principle of the transactive memory system, but without the need to communicate with the others. (2) If communication is indeed helpful in a typical CSCL situation, groups will outperform even those individuals who have access to the knowledge elements of their partners without being cognitively overloaded.

2 Experimental Study

In this empirical study it is investigated whether in virtual groups it is sufficient to know what the collaborators know and to which information resources the others have access (i.e., to have knowledge and information awareness), in order to be able to solve problems effectively, or whether the possibility to discuss with spatially distributed group members and thus, to collaborate, is also needed. To answer this question, we compared a control condition - in which the group members were only informed with regard to their cooperation partners' knowledge and underlying information, but could not communicate with each other - with an experimental condition in which the group members were both informed with regard to the others' knowledge and information as well as able to communicate and collaborate with each other.

According to the results of the study of Engelmann et al. (2010) and the study of Engelmann and Hesse (2010) it can be assumed that the availability of a tool for fostering knowledge and information awareness in fact enhances knowledge and information awareness. However, it can be expected that having the possibility to discuss contents with others will also contribute to the enhancement of knowledge and information awareness. Therefore, we propose the following:

- Hypothesis 1: The experimental condition will acquire more knowledge and information awareness compared to the control condition, because in the experimental condition there are two possibilities to foster knowledge and information awareness, namely being informed with regard to the others' knowledge and information via the tool applied and being able to discuss their knowledge and information among each other.

Having the possibility to generate more knowledge and information awareness and to clarify ambiguous aspects should have a positive impact on problem-solving activities:

- Hypothesis 2: The experimental condition will create digital concept maps, containing the structured task-relevant aspects that are more suited for solving the problems compared to the maps created by the control condition.
- Hypothesis 3: Therefore, the experimental condition will be more successful in solving the problems compared to the control condition.

3 Method

3.1 Participants

Participants were 81 university students (53 female, 28 male) of different fields of study. The average age was 23.60 years (SD = 3.25). The students were randomly assigned to 20 triads in the experimental condition and 21 simulated triads in the control condition. Each triad in the experimental condition consisted of an expert a, an expert b, and an expert c (N = 60). In the control condition, each participant was also randomly assigned to the role of expert a, b, or c, resulting in seven experts named a, b, and c. In the control condition, however, the two partners of the participant were simulated. There was no significant sex difference between the two conditions.

3.2 Materials and Procedure

In the experimental condition, the participants worked in groups of three students, each sitting in a separate room. In the control condition, the participants worked alone each sitting also in his/her own room. Each of the rooms was equipped with a desktop computer. In the problem-solving phase, group members of the experimental condition could communicate with each other by using Skype, a free internet phone software. In the control condition, the participants did not have the possibility to communicate with the others. The experimental environment was realized by using CmapTools, a digital concept mapping software developed by the Florida Institute of Human and Machine Cognition (USA).

The experimental environment used in this study provided information elements that are necessary for the rescue of a fictitious kind of spruce forest. These information elements consisted of 13 concepts, 30 relations between these concepts, and 13 (task irrelevant) background information elements, and were evenly distributed among the three group members in the experimental condition and among the three assumed group members in the control condition. Each participant had access to several concepts, relations, and background information that were unshared, shared with one (assumed) collaborator, or shared with both (assumed) collaborators.

The participants started with an online test aimed at assessing control variables, such as experience with computers, mapping techniques, and group work. Afterwards, they practiced using the applied software CmapTools until they could handle it without any problems. After practicing, they started with individual phase 1 of the experiment. At the outset of this phase, participants were told that they are experts who have to protect a spruce forest and that they first have to "refresh" their domain expertise before they start to collaborate to find a common solution for the problems. During this individual phase 1, which lasted 10 minutes, each group member was provided with her/his own digital concept map showing the conceptual knowledge (i.e., concepts and relations) and background information (underlying the conceptual knowledge), they had to refresh. In the individual phase 2, each participant had 5 minutes to view her/his own map as well as the maps of her/his (actual or assumed) collaborators.

After this activity, the participants were asked to fill out a paper-pencil questionnaire containing 15 multiple choice items to measure whether they had already acquired knowledge and information awareness. Subsequently in the problem-solving phase, the participants had to solve two problems, that is, which pesticide and which fertilizer they would use to protect and to cultivate the spruce forest. They had to start with the pesticide problem, because only

if the correct solution was chosen, the fertilizer problem could be correctly solved, that is, the fertilizer problem was based on the pesticide problem. The participants were told that they should start with the pesticide problem and that there was only one possible correct solution for each problem. In the experimental condition, to solve these problems collaboratively, the group members needed to compile the knowledge and information that they had refreshed in the individual phase 1. To do this, they used a shared working window to create a mutual digital concept map containing the knowledge and information they were provided with in the individual phase. During this phase, they could speak with each other. In the control condition, the participants were informed that their collaborators were recalled short-term in order to solve another urgent problem. Therefore, the participants were told to solve the two problems without the others. However, they had access to the knowledge and information resources of the collaborators, that is, they could use the digital concept maps of the others. Both conditions had 40 minutes for solving the problems. In both conditions, the participants could see their own working window, the shared working window, as well as the individual maps of their (assumed) collaborators; that is, they were provided with a tool fostering their awareness regarding the externalized knowledge and its underlying information of their (assumed) collaborators (Figure 1).

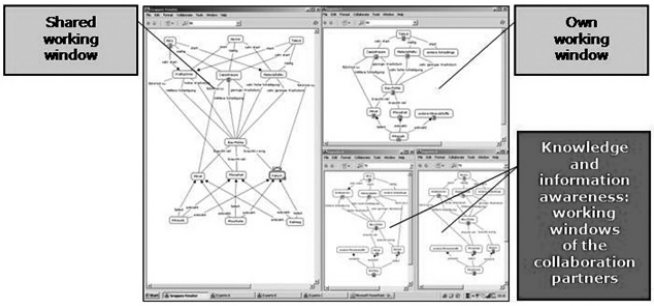


Figure 1. Screen in the problem-solving phase

After this problem-solving phase, the participants were given another test to measure their knowledge and information awareness. In this test phase, the experimental environment was no longer available. There were no time limits on this test. At the end of the study, participants worked on a questionnaire to evaluate the study regarding, for example, difficulties in using CmapTools or the need to communicate or collaborate with others.

3.3 Design and Dependent Measures

The analysis was based on a statistical comparison of the experimental condition and the control condition. In the experimental condition, the participants were not only provided with a tool for fostering knowledge and information awareness, they were also able to communicate with the others about the contents of the environment. In the control condition, the group members were also provided with a tool for fostering knowledge and information awareness, but they were not able to communicate with the others. In order to be able to compare the group values of the experimental condition and the values of the simulated groups of the control condition, in the experimental condition, the group means were calculated for each variable resulting in 20 group values for each measurement; in the control condition, the individual values were used. The reason for choosing this method of analysis is based on the main output level: The groups in the experimental condition created one common concept map as well as two common problem-solving solutions, while in the simulated groups, each individual participant also created one concept map and two problem-solving solutions. Therefore, the main output for each of the two conditions could be compared directly. An alpha level of .05 was used for all statistical tests. The dependent measures were:

3.3.1 Test of Knowledge and Information Awareness After the Problem-Solving Phase

The test consisted of 36 multiple-choice items. The items were classified among others with regard to who possessed the knowledge or information asked for (i.e., whether only oneself, only one of the (assumed) collaborators, oneself and one of the (assumed) collaborators, or only both (assumed) collaborators possessed the data). However, regarding the knowledge and information awareness concept, only the categories “only one of the (assumed) collaborators possessed the data” (max. 14 attainable points) and “only both (assumed) collaborators possessed the data” (max. 9 attainable points) are relevant. For each correct answer one point was given.

3.3.2 The Quality of the Created Concept Map

In order to analyze the quality of the created maps, the maps were compared to an expert's map. Five dependent variables were assessed: the number of correct nodes (max. 13 attainable points), the number of correct relations (max. 30 attainable points), the number of wrong nodes (no limit regarding attainable points), the number of wrong relations (no limit regarding attainable points), and the number of (task irrelevant) background information (max. 13 attainable points). For each entry of each category one point was given.

3.3.3 The Quality of the Answers to the two Problem-Solving Tasks

In this context, it was differentiated between the correctness of a solution and the correctness of the reasons given for a correct solution. The reasons given by the groups in the experimental condition and the individuals in the control condition were compared to the reasons given by an expert response. For each correct solution, one point was given. Only if the correct solution was found, the reasons given were analyzed according to an analysis schema with 0 points for a completely wrong answer and up to 3 points for a completely correct answer. Whenever the solution was wrong, zero points were given for the reasons. Two independent raters analyzed the reasons given by the groups. The interrater agreements were calculated: Regarding the reasons given as to why they chose the correct pesticide, Cohen's kappa was $\kappa = 0.86$ (cf. Cohen 1960). With regard to the reasons given as to why they chose the correct fertilizer Cohen's kappa for interrater agreement was $\kappa = 0.93$.

3.3.4 Subjective Evaluation of Study Aspects

The questionnaire contained five-point rating scale items ranging from 1 for no agreement to 5 for complete agreement concerning the evaluation of the study and the use of CmapTools. In the experimental condition, the communication and collaboration was evaluated; in the control condition, it was asked whether it would have been helpful to be able to communicate or collaborate with others. Due to the differences concerning the communication possibility between the conditions, there were 51 items in the experimental condition and 60 items in the control condition.

3.3.5 Manipulation Check

As a manipulation check at the end of the study, we asked participants in the control condition by means of a 5-point rating scale item, ranging from 5 points for complete agreement and 1 for no agreement, if they thought at beginning of the experiment that this was a study in which they had to cooperate with others.

4 Results

With regard to the 25 control measure items (e.g., experience in group work), a factor analysis with Varimax rotation was conducted resulting in 3 interpretable factors with eigenvalues higher than 1. The factors were called "Experience with Concept Maps", "Preferences Regarding Group Work", and "Experience in Working with Computers". For each of these factors a univariate ANOVA was performed showing that there were no significant differences between the two conditions. Therefore, the inclusion of a covariate was not necessary.

Partial eta-squared values ($\eta p2$) as a descriptive index of strength of association between the experimental factor and a dependent variable are reported in this paper (Cohen, 1973). Such a value is defined as "the proportion of total variance attributable to the factor", excluding other factors' impact (Pierce, Block, & Aguinis, 2004, p. 918).

Regarding the analysis of the manipulation check item, we found that only 11 of the 21 participants in the control condition believed that this was a group experiment, while 7 participants did not believe it and 3 participants were undecided.

In contrast to our hypothesis 1, postulating that the experimental condition outperforms the control condition regarding the amount of acquired knowledge and information awareness, the analysis of the knowledge and information awareness test after the problem-solving phase did not show significant differences between the conditions (Information that only one of the others had: $F < 1$; Information that both of the others had: $MC = 6.9$, $ME = 6.2$, $F(1,39) =$

1.95, MSE = 2.43, $p > .05$).

Even though there was no difference on the amount of knowledge and information awareness between the conditions, significant effects were found in the problem-solving performance: With regard to the concept maps that had to be created in order to be able to solve the problems, the analyses showed that in the control condition, the created concept maps for solving the problems contained more wrong relations (MC = 4.67; ME = 1.25; $F(1,39) = 9.25$; MSE = 12.93; $p < .05$; $\eta p2 = .19$). This result is accordant to our hypothesis 2. However, there were no significant differences regarding the other concept map measurements.

The mistakes in the concept map seem to have an impact on the correctness of the problem-solving answers: The analysis of the problem-solving tasks showed indeed no significant differences regarding the correctness of the pesticide problem ($F < 1$) and the reasons given why this answer is chosen (MC = 1.57; ME = 2.1; $F(1,39) = 2.19$; MSE = 1.31; $p > .05$), however, regarding the fertilizer problem, the experimental condition outperformed the control condition with regard to the frequency of the correct solution (MC = 0.62; ME = 0.95; $F(1,39) = 7.41$; MSE = 0.15; $p < .05$; $\eta p2 = .16$) and with regard to the correctness of the reasons given as to why this answer was chosen (MC = 1.19; ME = 2.10; $F(1,39) = 10.00$; MSE = 0.85; $p < .01$; $\eta p2 = .20$). Here it should be noted that the fertilizer problem is a more complex problem compared to the pesticide problem because it builds on the pesticide problem; that is, it can only be solved correctly if the pesticide problem is done correctly. Our hypotheses 3 could thus be partly confirmed.

To analyze the questionnaire for evaluating different study aspects, a factor analysis with Varimax rotation was conducted. We found 3 interpretable factors with eigenvalues higher than 1. Univariate ANOVAs for each factor resulted in one significant difference between the two conditions: The participants in the experimental condition were more confident that they solved the problems correctly and they felt less stressed while participating in the study compared to the control condition (MC = -0.43; ME = 0.45; $F(1,39) = 9.43$; MSE = 0.83.; $p < .01$; $\eta p2 = .20$).

5 Summary and Discussion

According to Wegner's theory of transactive memory systems (Wegner, 1986), group members do not need to share all information, instead in groups it is sufficient to know who of the other group members knows what. However, he highlighted the importance of communication between the group members, for example, in order to establish a transactive memory system or to retrieve information saved in the group. Other areas of research, however, showed that sometimes communication can cause problems that lead to decreased group performance. In this paper, we investigated the role of communication in a situation in which the group members had direct access to a representation of the externalized knowledge and information of the other group members. We compared an experimental condition in which the spatially distributed group members were provided with the described representation and were also able to communicate with each other, with a control condition in which participants worked alone and had only access to this representation without being able to communicate with the others.

We expected that both the access to the externalized knowledge and information of the others as well as the communication foster knowledge and information awareness (i.e., being informed with regard to the knowledge and its underlying information of the collaboration partners). Therefore, we hypothesized that the experimental condition acquires more knowledge and information awareness compared to the control condition (see hypothesis 1). However, we found no difference between the conditions. Having the possibility to use the tool applied seems to be sufficient to acquire knowledge and information awareness. The additional possibility to communicate with the others did not result in an increased amount of knowledge and information awareness. This could be caused by a ceiling effect, that is, in this situation, the applied tool alone was sufficient to foster knowledge and information awareness. In addition, a reason could be that tools such as the applied one are, in general, efficient enough to foster knowledge and information awareness. Another explanation could be that in the control condition the participants were keen to acquire knowledge and information awareness, because they had to solve the task by themselves, whereas knowledge and information awareness was acquired casually in the experimental condition. This interpretation is corroborated by the result of the manipulation check showing that only slightly more than the half of participants in the control condition believed that this was a group experiment. Even though there were no significant differences regarding the acquired knowledge and information awareness, we found significant effects in performances: The participants of the control condition included more incorrect relations in their maps. This is accordant to hypothesis 2. Therefore, the possibility to communicate

with others seems to reduce mistakes in the maps. This is in accordance with empirical findings of other former studies showing that group members tend to correct diverse types of errors mutually which improves their performance compared to individuals (e.g., Hinsz, 1990; Vollrath, Sheppard, Hinsz & Davis, 1989). The hypothesis 3 could be confirmed for the complex fertilizer problem: The possibility to communicate with others seems to have a positive impact on solving the complex task: We found that the experimental condition outperformed the control condition in the complex problem-solving task, but not regarding the easier task. This is in line with Hirokawa (1999), postulating that communication becomes particularly important if the structure of the problem-solving task is complex. This is also accordant to the findings of Wilson, Timmel, and Miller (2004) showing that interacting groups are superior to individuals if solving the tasks exceeds the capacity of individuals (Wilson et al., 2004). In addition, we found that the groups of the experimental condition felt less stressed and were more confident that their solutions were correct compared to the control condition. This may be explained by findings of other studies showing that collaborative learning and problem solving leads to more satisfaction compared to individual learning (e.g., Benbunan-Fich & Hiltz, 1999). These results lead to the conclusion that communication plays a crucial role for group performance. The findings show that it is not enough to be informed with regard to the others' knowledge and information, communication is also important.

It may be argued, however, that additional reasons were responsible for the superiority of the experimental condition over the control condition: The fact that participants in the experimental condition could communicate and, therefore, collaborate for solving the problems may have led to information processing characteristics or problem-solving strategies that differed from those of the participants of the simulated groups, that is, of the control condition. For example, groups can apply more effective decision-making strategies, because the members can provide various judgments that can be weighted differently (e.g., Vollrath et al., 1989). In our study, the group members of the experimental condition could suggest different solutions and could discuss which one could be correct. In the control condition, the participant could not communicate with the others and perhaps was not able to find or not willing to consider alternatives to her/his own solution. However, as already mentioned, collaboration could have also been a hindrance for group performance. Tindale and Sheffey (2002), for example, found in their experiment that collaboration did not improve group memory performance in terms of number of recalled items. The authors interpret this result in terms of production blocking and social loafing that may have occurred in the condition with interacting groups. Further studies are needed that investigate the role of collaboration if the group members are provided with a tool for fostering knowledge and information awareness. For example, the question should be answered whether information processing or problem-solving strategies of groups using a tool for fostering knowledge and information awareness differ from those of individuals who also have access to this tool.

To sum up, with the study described in this paper, we could show that although the group members had direct access to the externalized knowledge and information of the other group members and therefore had knowledge and information awareness, it was also necessary to be able to communicate with the others in order to perform effectively in complex problem-solving tasks.

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Concept Maps: Making Learning Meaningful
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THE DEVELOPMENT OF A SELECT-AND-FILL-IN CONCEPT MAP ASSESSMENT OF HUMAN GEOGRAPHY KNOWLEDGE

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Abstract. The purpose of this paper is to report the decision process in choosing a concept mapping task to assess the human geography knowledge of middle school students participating in an after-school college reach-out program, Pre-Collegiate Connections Program. Research is presented supporting construct-a-map and fill-in concept mapping tasks. The final map, a select-and-fill-in task, was developed and field-tested with 43 students during the first week of May 2010. Analyses indicated that, across all three grades, the omitted concepts were moderately difficult and exhibited a Cronbach's alpha of .84.

1 Introduction

The overall purpose of this project was to develop a measure of the human geography knowledge of middle school students participating in an after-school college reach-out program, Pre-Collegiate Connections Program (P-CCP). P-CCP was first implemented during the 2007-2008 academic year. The participating students attended two low-performing middle schools in the urban core of a large American city located in a southeastern state. During the first year, the content of the program was designed for and offered to sixth graders. Seventh-grade content was designed, and P-CCP was offered to sixth and seventh graders during the 2008-2009 academic year. By the third year of implementation, the 2009-2010 academic year, design work was complete, and P-CCP was fully implemented across all three middle school grades.

At each grade, the academic content of P-CCP is focused on human geography. This choice was motivated by the offering of AP Human Geography in the ninth grade in all district high schools. Thus, a P-CCP goal is to help students develop the core content knowledge of human geography in hopes that this will motivate participants to enroll in and subsequently to be successful in AP Human Geography. P-CCP developers see meeting this goal as a major indicator of successful efforts toward ensuring that P-CCP participants see themselves as college bound students.

Students are eligible to participate in P-CCP based on a combination of several factors including below grade-level achievement on the state reading and/or mathematics accountability measures; poverty-status determined by eligibility for the Free and Reduced Lunch Program, funded through the National School Lunch Act; and /or the potential for being a member of the first generation in their family to attend and complete college. During the 2009-2010 academic year 74, 70, and 58 students participated in the sixth-, seventh-, and eighth-grade P-CCP initiative, respectively.

Two aspects of the P-CCP curriculum effected our decision to field test a concept mapping evaluation of participants' knowledge of the 3-year P-CCP human geography curriculum content. The first aspect is that the P-CCP curriculum was developed using a backward design process (Wiggins & McTighe, 2005). The backward design process provides a detailed table of specification describing curriculum goals, and the table was available to the assessment developers. Second, concept mapping was used as an instructional strategy in all three grades of implementation. Thus, the use of concept mapping assessments would not require providing concept mapping training to the students prior to the assessment.

2 Using Concept Mapping for Assessment

Concept mapping has long been seen as a powerful tool to promote meaningful learning (e.g., Kinchin, 2000; Kinchin

& Hay, 2000; Novak, 1990; Novak, 1998; Novak & Cañas, 2008; Novak & Gowin, 1984). Four primary uses for concept mapping were suggested by Novak: for learning, instruction, planning, and assessment (1990). However, the use of concept mapping for assessment has not been as popular as its use for instruction (see Broers, 2009; Kinchin, 2000; Ruiz-Primo & Shavelson, 1996). When concept mapping tasks are used for assessment, the purpose is most often to measure the mapper's knowledge structures and validity studies have generally addressed this purpose. However, for those interested in using concept mapping for assessments, decisions need to be made about the three assessment-related facets of a concept mapping framework developed by Ruiz-Primo and Shavelson as well as potential trade-offs between efficiency and validity resulting from the decisions.

The proposed assessment-related framework describes concept map production as the interrelationship of three map facets: task for the respondent, format of the response, and a scoring system that produces reliable and valid results (Ruiz-Primo & Shavelson, 1996). The gold standard is student-generated concept maps that involve no constraints; however, as pointed out by several researchers (see Broers, 2009; Yin,Vanides, Ruiz-Primo, Ayaly, & Shavelson 2005), unconstrained student-generated maps can be idiosyncratic. Ruiz-Primo and Shavelson described three ways the concept mapping task draws out students' knowledge: task demands, task constraints, and task structure. Task demands for students range from the heavy cognitive demand of student-generated concept map formats to the more moderate demands of fill-in type concept map formats. Task constraints involve restrictions imposed on the task. For instance, students may be supplied a list of concept to use, asked to construct an hierarchical map, supplied a list of linking phrases, or provided a map structure to fill in. The structure of the task results from combining the task demands and the constraints.

Numerous scoring systems have been proposed and studied, with most systems building on the work of Novak and Gowin (1984) in which the number of propositions, cross-links, and the concept maps' hierarchical structures receive scores. McClure and Bell (1990) studied six scoring methods involving holistic, rational, and structural scoring used alone and in conjunction with a master map. Ruiz-Primo and Shavelson (1996) provided a detailed list of scoring systems available at that time. West, Park, Pomeroy and Sandoval (2002) studied structural and relational scoring systems. Kinchin (2000) and Kinchin and Hays (2000) suggested a two-tier system that provides a qualitative approach assessing the overall map structure (chain, spoke, and net) as well as the structural features. Leake, Maguitman, & Reichherzer (2004) proposed a scoring system to quantify the importance of concepts by measuring the number of links going into and out of concepts nodes. However, at this point, there is no universally recommended scoring system, and researchers continue to develop and study scoring systems in efforts to better measure the structure of knowledge and to automate the use of developed scoring systems.

2.1 Studies by Ruiz-Primo and Her Colleagues

Concept mapping tasks that constrain students' construct-a-map task by providing a list of concepts and fill-in concept mapping tasks that constrain students by providing combinations of map structure, concepts, and linking phrases are important to P-CCP decisions. Ruiz-Primo, Schultz, Li, and Shavelson (2001) studied the validity of three types of maps frequently used for assessing science achievement: construct-a-map with a concept list provided; fill-in-concept maps with a list of omitted concepts, in-place concepts, linking phrases, and map structure provided; and fill-in-linking phrases maps with a list of omitted linking phrases, in-place linking phrases, concepts, and concept map task with map structure provided. Research participants were high school chemistry students. The construct-a-map task was not constrained in any manner other than the provision of 20 concepts. Analyses resulted in two findings relevant to P-CCP decisions. First, fill-in-concept and fill-in-linking phrase maps are not equivalent measures. Students generally found fill-in-linking phrases to be more difficult. Second, construct-a-map tasks better reflect differences among students' knowledge.

Ruiz-Primo, Shavelson, Li, and Schultz (2001) used think-aloud techniques to gain insight into the cognitive activities that high school chemistry students used relative to performance on the concept mapping tasks. Construct-a-map responders used slightly more explanation activities (39.1%) than monitoring activities (28.2%). Fill-in map responders used more monitoring activities (40.9%) than explanation activities (4.6%). Explanation activities were described as defining the response by providing relative details, comparing and contrasting information, and justifying responses. Monitoring activities were described as the application of a strategy for performing the task, use of effective reflection that acknowledged a problem and formed a solution, use of ineffective reflection that acknowledged a problem but offered no solution, use of self-checking, and use of reviewing the task performance for accuracy.

Students completing fill-in concept map tasks were more aware of accuracy than when completing construct-a-map tasks. Thus, researchers concluded that the low-constrained construct-a-map tasks allow students more opportunity to use conceptual knowledge to complete the task while more-constrained fill-in maps encourage students to closely monitor the accuracy of their responses.

Concept mapping tasks were also evaluated across proficiency groups which included concept maps produced by teachers, low-performing students, and high-performing students. Ruiz-Primo, Shavelson, et al. (2001) reported that a higher percentage of low-performing students used monitoring activities than high-performing students, and that when low-performing students completed construct-a-map tasks, think-aloud techniques revealed "The low-performing student read all the concepts, selected one with no apparent justification for doing so, and started drawing the map" (p. 125).

The work of Ruiz-Primo, Shavelson, et al. (2001) indicated that fill-in map formats may not measure the same construct as construct-a-map formats; however, we were equally concerned about their finding that low-performing high school chemistry students may not be up to the cognitive demand of construct-a-map formats. All of the P-CCP participants attend low-performing middle schools and are most likely performing below grade-level on one or more of the state's accountability measures. Thus, we questioned whether the construct-a-map task would reflect P-CCP students' human geography knowledge.

2.2 Studies by Schau and Her Colleague

Schau and her colleagues (Schau & Mattern, 1997; Schau, Mattern, Zeilik, Teague, & Weber, 2001) also studied the use of the fill-in concept map format for assessments because they believed that while construct-a-map tasks could be useful for classroom assessments of connected learning, that construct-a-map tasks have limitations. These limitations include the lack of a universally accepted scoring system, the amount of time required to complete the task, proficiency of concept mapping skills required for students to perform the task, and the imposition of high levels of cognitive demand on the responding students (Schau & Mattern, 1997). P-CCP students are rarely described as high performing; therefore, a concern is that, in Schau and Mattern's view, the cognitive demand of construct-a map may be more problematic for low-performing students

Schau et al. (2001) provided detailed research on the development and use of fill-in concept map formats with middle school science students and undergraduate students enrolled in an introductory astronomy course. The development of fill-in maps and their relationship to multiple choice tests that measure the same constructs is relevant to the P-CCP study. Schau et al. developed a variety of fill-in type maps (22 in all) and then evaluated the types with middle school science students. A non-exhaustive list of studied formats included a variety of response formats such as, which elements were omitted (concepts or linking phrases), how many elements were omitted, and the relative placement of the omitted elements. Results of their evaluation narrowed the list of 22 fill-in map types to two formats with non-consecutive concepts omitted. Think alouds, conducted with 12 students, revealed two important outcomes: students accepted the task and no differences were detected in how students approached the concept mapping task when the response format was a paper and pencil task or involved the manipulation of movable pieces.

The concept mapping format that was subsequently studied was a select-and-fill-in (SAFI) concept map with up to 50% of the non-consecutive concepts removed. Field testing resulted in a final version with 36% (38) of the 105 concepts removed. Scores on this SAFI concept map, reflecting the percent of correct responses, were compared to a 27-item multiple choice test. Cronbach's alpha for the SAFI was .94 and for the multiple choice .85. The instruments were tested across seventh- and eighth-grade science students with differential expectations for outcomes. Results indicated that, on average, eighth graders scored 66% correct and seventh graders scored 58% correct. This pattern matched that obtained using the multiple choice tests.

3 Decision to Use SAFI Concept Maps to Assess Human Geography Knowledge

After reviewing the work of Ruiz-Primo and her colleagues (Ruiz-Primo & Shavelson, 1996; Ruiz-Primo, Shavelson, et al., 2001; Ruiz-Primo, Schultz, et al. 2001) and Schau and her colleagues (Schau & Mattern, 1997; Schau et al., 2001), we decided to develop a SAFI concept map similar to the one developed and tested by Schau et al. Several

factors influenced our decision. We agreed with Schau and Mattern that the task in student-generated concept maps could potentially place a high cognitive demand on low-achieving students. Ruiz-Primo, Shavelson, et al. reported think aloud findings indicating that low-performing students did not develop strategies to complete construct-a-map tasks rather they began the task seemingly at random. We also think that the use of monitoring activities in performing fill-in concept mapping tasks is a positive outcome especially when the activities lead to effective reflection, checking, and developing task completion strategies.

We were further influenced by the work of Schau et al. (2001). Their first reported study involved middle school students and included some students similar to P-CCP students. We believe that it is important that the studied middle school students accepted the task; moreover, the fact that some even enjoyed the concept mapping task was impressive. P-CCP students have had numerous experiences with testing as part of high-stakes, accountability assessments, and the students have not necessarily enjoyed positive outcomes. Furthermore, P-CCP participation is entirely voluntary, and students frequently choose P-CCP participation over competing, less academically focused after-school programs. Thus, it is in everyone's best interest that we evaluate P-CCP human geography knowledge with novel methods that students see as a pleasant activity rather than as just another high-stakes assessment. We plan to use the developed instrument across all implementation grades; therefore, we expect differentiated outcomes. At this time, however, in deference to Ruiz-Primo, Shavelson, et al. (2001), we refrain from suggesting that we are measuring the human geography knowledge structure of the P-CCP students.

4 Development of the P-CCP Human Geography SAFI Map

SAFI formats are created in two steps; the first is the creation of a master map by an expert, often the teacher. Then, the expert omits some or all of the concepts or linking phrases. Students are then asked to fill-in what is omitted by selecting from a list of provided concepts (Schau & Mattern, 1997).

The design of the P-CCP curriculum resulted in the creation of a table of specification for each grade. The first step in master concept map creation was to locate all of the concepts in the table of specification for each grade. Table 1 shows the resulting list of identified concepts. In looking at the table of concepts, it became obvious that the curriculum was designed from the bottom-up starting at the sixth grade with self, family, and neighborhood. By the eighth grade, the curriculum had expanded to the more global concepts of nation states. The identified concepts led to internal discussions of the big ideas of human geography—the big ideas that form the first levels of a top-down hierarchical map and that are missing from the concepts listed in Table 1.

The research team collectively realized that they did not have the human geography expertise to place a reasonable number of the concepts listed in Table 1 in an expert P-CCP human geography concept map—especially one that would encompass all three grades. The resulting concept map would map the top-down hierarchy of human geography and include the Table 1 concepts. At this point, a human geography expert from the Economics Department at a local university agreed to join the research team to assist in the creation of the expert map. After lengthy discussions of the concept list and armed with The Cultural Landscape: An Introduction to Human Geography-Tenth Edition, (Rubenstein, 2011), a first draft of an expert concept map was completed. The first attempt at constructing the expert concept map incorporated the discussions with the human geography expert by adding the big ideas using generic terms that the P-CCP students would understand. The final SAFI concept map, shown in Figure 2, was agreed upon by the human geography expert and the P-CCP implementation team. The SAFI concept map contained 72 concepts, some of which are not included in Table 1 and some concepts listed in Table 1 were not included on the SAFI concept map.

The final SAFI concept map, omitting 20 concepts, is shown in Figure 2—the omitted concepts are shown in Figure 1. In keeping with the SAFI concept map developed by Schau et al. (2001), consecutive concepts were not removed in the human geography SAFI concept map. Thus, most of the omitted concepts are at the bottom of the map (lower in the hierarchy).

5 Field Testing the P-CCP Human Geography SAFI Map

During the first week of May 2010, 43 P-CCP students agreed to field test the SAFI by completing the puzzle as part of their routine after-school activities. The sample of 29 girls and 14 boys included 23, 13, and 7 sixth-, seventh- and

eighth graders, respectively. Student responses, coded 1 for correct responses and 0 for incorrect responses) were analyzed to determine item (omitted concept) difficulty, item differentiation by grade, differentiation by gender, and Cronbach's alpha. Results of the analyses are presented in Table 2.

When all omitted concepts are considered across all grades, the SAFI exhibited an acceptable coefficient of internal consistency, .84, and only one concept (outside influences from the sixth-grade curriculum) was difficult with an estimated mean of .279. However, more than 90% of the students correctly used three of the omitted concepts (two from the seventh-grade and one from the eighth grade curriculum). In looking at the difficulty of omitted concepts across gender, 90% of the boys correctly used five omitted concepts and 90% of the girls correctly used three. Two omitted concepts from the sixth-grade curriculum presented difficulty for the boys. Cronbach's alpha calculated for boys and girls was nearly the same at .85 for boys and .84 for girls. A slightly different picture emerged when SAFI concepts were analyzed for each grade. The sixth-graders struggled with concepts from the sixth-grade curriculum while they found concepts from the seventh- and eighth-grade curricula easy. In fact, Cronbach's alpha for the four sixth-grade omitted concepts was an unacceptable .36. The seventh-graders somewhat struggled with the sixth-grade omitted concepts but they found the difficulty of most of the seventh-grade curriculum omitted concepts reasonable. Moreover, Cronbach's alpha for the 10 seventh-grade curriculum omitted concepts was .83 which is close to the value for all 20 items. All eighth-graders correctly used four omitted concepts, two from the seventh-grade curriculum and two from the eighth-grade curriculum. Cronbach's alpha for the 7 eighth-grade curriculum omitted concepts was .73 which could be improved, but is acceptable.

Eighth Grade	Seventh Grade	Sixth Grade
Sovereignty	**Jacksonville**	Productive teams
Personal choices	**Beaches**	Emotions
Nation-states (Countries)	**Rivers**	**Behaviors**
Interdependence	**Flatlands**	Future
Domino theory	**Marsh lands**	**Goals**
Developing countries	**Forests**	**Barriers**
Socioeconomic welfare	**Local government**	Likes/dislikes
Economic development (Production)	**Mayor**	Strengths/weaknesses
Gross Domestic Product	**City council members**	Follow through/problem solving
Underdeveloped countries	**Judges**	Life experiences
Birth rate	**Representatives**	**Outside influences**
Death rate	**Revenue**	Personal characteristics
Life expectancy	**Flora**	**Expectations**
Political instability	**Fauna**	Communication
Disease	Indigenous	Social skills
Push factors	**St. Johns River**	**Historical events**
Pull factors	Settlers (Jacksonville)	**Family traditions**
Landmarks	**Migrate**	Genealogy
Cultural significance	**Economic activities (production)**	**Neighborhood**
Governmental practices	Geography	Map features
Resources	**State government**	Map production
Symbolism	Spanish explorers	Community well-being
Flag	**St. Augustine**	School well-being
National Anthem	**Tourism**	**Migration**
Environment	Jobs	James Weldon Johnson
Depletions of Natural Resources	Tax base	**Compass Rose**
Pollutions	Northern transplants	**Self concept**
Conflicts	**Immigrant laborers**	
United Nations	Refugees	
United Nations Headquarters	**Physical characteristics (geographic regions)**	
International peace	**Man-made characteristics**	
Security	Political parties	
United Nations Organs (6)	**Distributions of resources**	
	Carbon	
	Atmosphere	
	Landmark (man-made and natural)	
	Memorable sites	
	Travel	

Table 1. P-CCP Human Geography Concepts by Grade

Note. Bold-faced concepts in Table 1 represent concepts that developers included in the SAFI concept map in Figure 2. When language differed from the table of specification, those differences represent concepts of importance, big ideas, to the field of human geography content. SAFI developers attempted to use both the language of Rubenstein (2011) and the curriculum table of specifications in labeling the concepts.

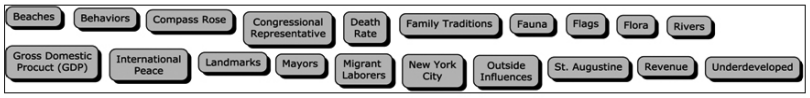


Figure 1. Omitted concept bank

Note. The Figure presents the list of 20 concepts for students to use to fill-in the omitted concepts indicated on the concept map in Figure 2. Students are to use all concepts and to use each concept only once.

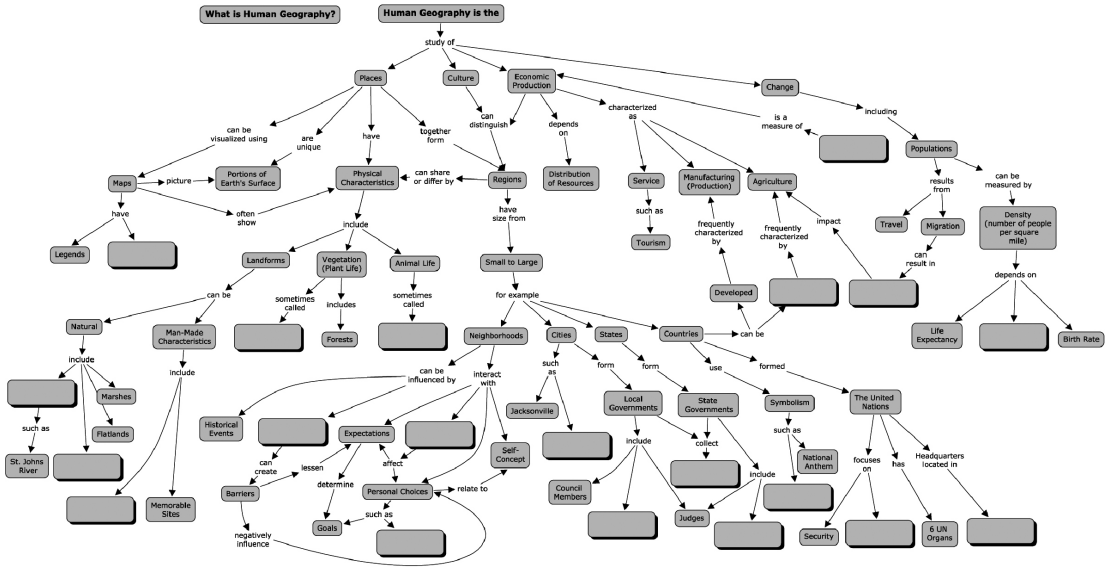


Figure 2. SAFI human geography concept map

				Mean			
	Item grade	all	6th	7th	8th	Males	Females
Items							
Compass Rose	6	.884	**.957**	.769	.857	**1.000**	.828
Outside Influences	6	*.279*	*.217*	.308	.429	*.214*	.310
Behaviors	6	.488	.522	.308	.714	.500	.483
Family Traditions	6	.302	*.217*	.462	*.286*	*.143*	.379
Rivers	7	.860	.870	.846	.857	**1.000**	.793
Beaches	7	.837	.783	**.923**	.857	**.929**	.793
Flora	7	**.930**	**1.000**	.769	**1.000**	**.929**	**.931**
Fauna	7	**.907**	**.913**	.846	**1.000**	.857	**.931**
St. Augustine	7	.605	.652	.385	.857	**.929**	.448
Mayors	7	.674	.652	.769	.571	.571	.724
Revenue	7	.674	.652	.615	.857	.643	.690
Congressional Rep	7	.349	.304	.462	*.286*	*.286*	.379
Migrant Workers	7	.628	.696	.462	.714	.643	.621
Landmarks	7 & 8	.605	.652	.462	.714	.643	.586
Flags	8	.651	.739	.462	.714	.643	.655
International Peace	8	.581	.565	.538	.714	.643	.552
New York City	8	.628	.652	.462	.857	.857	.517
Underdeveloped Country	8	.488	.391	.538	.714	.500	.483
Death Rate	8	**.930**	**.957**	.846	**1.000**	**.929**	**.931**
GDP	8	.465	.391	.308	**1.000**	.714	.345
Total Score	All	63.837	63.913	57.692	75.000	67.857	61.867
Coefficient Alpha		.84	.36[a]	.83[b]	.73[c]	.85	.84

Table 2. P-CCP Human Geography SAFI Omitted Concept Means, Mean Scores, and Cronbach's Alpha by Grade and Gender

Note. Bolded values represent very easy omitted concepts and italicized values represent difficult omitted concepts. a

indicates that only omitted concepts specified for the sixth-grade curriculum (4) were used in calculations; b indicates that only omitted concept specified for the seventh-grade curriculum (10) were used in calculations; and c indicates that only omitted concepts specified for the eighth-grade curriculum (7) were used in calculations.

6 Future Research Geography SAFI Map

Analysis of the omitted concepts for grade-specific curricula points to the need for changing the selection of omitted sixth-grade concepts. Of the four concepts selected for omission, two were difficult for the sixth graders; furthermore, the four missing concepts represented some of the most difficult concept at all grades. One course of action is to revise the sixth-grade curriculum as well as the sixth-grade representation on the SAFI. The omitted seventh-grade concepts presented little difficulty for the sixth-graders, thus, the resulting SAFI scores did not differentiate the sixth- and seventh-graders as expected. P-CCP curriculum developers need to determine the extent that the seventh-grade curriculum represents new knowledge, old knowledge presented in a new context, or a review of previously learned material. Additionally, the omitted eighth-grade concepts presented little difficulty for the eighth-graders, and the 7 omitted eighth-grade concepts presented little difficulty for the sixth- or seventh-graders. However, only 7 eighth-grade students participated in the field test; therefore, eighth-grade results should be interpreted with caution.

At this point the research team has not investigated incorrect responses. Anecdotal evidence suggests that the omitted sixth grade concepts were generally used in sixth-grade concept positions, but in incorrect order. In general, the sixth-grade concepts are the most abstract of the SAFI concepts and represented the least generalizable connection to the human geography content structure. These observations need to be addressed in any revision of the curriculum or SAFI for the sixth-grade. Additionally, what developers thought would not be a difficult omitted concept, congressional representative, in fact, turned out to be moderately difficult across all three grades. Most incorrect responses placed this concept in the position intended for mayors—a placement indicating that congressional representatives are part of local governments. The congressional representative for the students' district is a local, very familiar person and could have lead to the students' confusion. This piece of the SAFI needs tweaking to add more clarity.

The research team feels that the SAFI presented in Figure 2 provided a good first step. In the process of revising the SAFI, researchers need to formally clarify the purpose of the developed instrument in evaluating P-CCP students' knowledge. Is the purpose to develop a criterion-referenced measure of students' absolute performance on items considered important to the human geography domain or whether the developers desire variation (beyond grade differentiation) in performance? If the desire is a criterion-referenced measure, the easy omitted concepts need to be evaluated for their importance to the curriculum objectives. Important concepts cannot be removed, but can be revised to add difficulty if appropriate.

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Concept Maps: Making Learning Meaningful
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THE LONG WAY TO DEEP UNDERSTANDING

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Abstract. The goal of deep understanding is still considered – in actual educational practices - more as an ideal limit with blurred edges than as a dutiful objective for all secondary school students, especially in scientific education. This achievement, along with decisive governance and professional changes in the educational systems, would be obtainable first by the mediation of linguistic tools (signs, meanings and senses) by their rule-governed use in language – a Vygotskyan development of an individual author's action-research, and the center of this paper - then by the organization of framework, mobilization and use of scientific concepts, and finally – in a psychological, not chronological sense - through diffuse problem-solving activities. In the last three years of teaching experience in Organic Chemistry in a secondary school, within the class context of three different groups of students, different practices of problem solving and writing tasks for mediation of concept change, which could be complementary to concept maps, have been tried out and discussed from the perspective of deep understanding.

1 Introducción

In the last three years, I have tried several approaches to empower meaningful learning and understanding, through in-class and online activities (through wikis and Google docs, linked to www.divini.net/chimica), proposing practices of collaborative problem-solving, trying activities of concept-texting with students aged from 16 to 18 on a three-year course at our Chemistry technical school. These practices have been oriented – from a curricular point of view - to the teaching/learning of Organic Chemistry, a discipline characterized by a) a specific language that is visual and verbal at the same time, b) a high autonomy from other chemical disciplines, c) a strongly deductive and logical constitution, d) a strategic and problem-solving approach, e) strong but indirect bonds to experience mediated by symbols (formulas and reaction mechanisms' schemes) and f) invisible concrete-material body of microscopic objects, molecules and forces, manageable only through logical imagination as is the case with other chemistry subjects.

The individual action-research route had roughly the following development:

In 2007-08 with group A (20 students), at the first of three year course in organic chemistry, being unsatisfied of previous attempts to implement concept mapping in the course, I managed to base the whole course on collaborative problem solving, with stages at home (through shared online documents), in laboratory and in-class.

In 2008-09 group A continued to work as before to the second grade curriculum topics progressing in blocks of questions and problems (both theoretical and experimental, differentiated for the five heterogeneous collaborative groups), with important changes in managing the organization of timing and strategies to maximize the involvement of all, and the sharing of knowledge intra- and inter-group (these changes, however being interesting, go beyond the design of this review). In the same year a new freshman group of ten students ("group B") started to work at blocks of focus or "stimulus" enquiring questions that had to be answered in five lines, writing short propositions with a reduced number of concepts and highlighting the most relevant concepts. This text structure was designed to prepare subsequent concept mapping activity on the related topics; at the same time it was intended as a concept texting task having more expressive freedom than the propositional structure possessed by Cmaps, in the perspective of attempting a subsequent comparison the two kinds of conceptual writing. Also this activity was given a collaborative form, mainly online (included pair and teacher reviewing) for the sake of finalizing home study, and leaving class time for concept mapping and applications of concepts and principles.

In 2009-10 group A, arrived at the third and last year of the course, continued to apply in elaborating whole class-group shared documents (because of the reduced involvement that remained restricted to a few students) about biochemistry topics. The online questionnaire had to be initially completed in collaboration by the whole class, completely autonomously. A reviewing and enhancing contribution by the teacher was given only at the end, to yield a complete

guide for studying the topic. The class group B, arrived to the second grade, after a substantially fault to collaborate in the concept texting tasks, and also to get advantages from concept mapping, was driven to a different form of questionnaire for each topic, to be answered individually (personal study diary) with possible contributes of a peer-reviewer. The objective was to give more feedback and to stimulate more changes and insights for each question and for each individual student. For the same reason the questions were more in-depth analyzed also in class discussions.

In this last school year also a new class group “C”, formed by 23 students entered in the first course year. During the first school months I observed more closely the ways these freshmen students where elaborating contents, solving problems and taking notes, and I saw their habit to register only the symbolic part of class contents, their habit of writing down sequences of transformations, also imitating other mates or the teacher in doing such actions, but always in such a way that many important words (concept labels) were lacking (orally substituted with "this", "that" etc.), so that the “discourse” of the process was systematically lost. My working hypotheses to explain this phenomena was that the mastery in the use of the new terms and associated lexicon was lacking. From such observations and interpretation I tried (January - April 2010) to put in action a different form of shorter pre-conceptual writing tasks, less demanding for enquiry. This action led also to a profitable strategy and a clearer role for the introduction of concept mapping.

The time is ripe for a first evaluation of the briefly outlined old and new practices which, in these years of experimentation, were aimed to the conquest of aptitudes for autonomous learning and deep understanding.

2 Deep Understanding

There are many ways to attempt a definition of deep understanding (e.g. Wiggins & McTighe, 2005). In any case, there are a few observable indicators that distinguish the aptitudes of a small group of students within the whole population. The distinguishing mark of deep understanding relies on challenging the learning contents.

These efforts to criticize and comprehend invariably produce an autonomous change of initial forms used to represent the object. In this sense, the term “deep” stands more for “distinctly individual” and personalized than for “in-depth”. Going along the general exam of deep understanding, D. Perkins in "Teaching for Understanding" (Perkins, 1997), also prefers to define "understanding" more as a «flexible performance capability to think and act flexibly with what one knows», rather than as some kind of an achieved understanding, i.e. a representation or image or a mental model that we have when we say, "I've got it". It is not guaranteed that in-depth study is apt enough to answer probing questions about fundamental, general or initial aspects inherent in a topic to satisfy the strive for understanding. This kind of thought is characterized by a stronger need for knowing “why are things as they are and not otherwise?”, an aptitude that is certainly required to answer the following questions that was posed in the last school year:

Ex.1 (group “A”, 3rd grade): ATP is a high-energy species, stable in water. It can be hydrolysed only by coupling the reaction with water along with some useful, non-spontaneous reaction. Why does the cell never produce enzymes that would be able to catalyze only the hydrolysis of ATP?

Ex.2 (group “B”, 2nd grade): Acyl halides are the strongest acylating substances; so which substance could ever acylate a halogen to yield an acyl halide?

Ex. 3 (group “C” 1st grade): Does butane contain the substance carbon?

True deep understanding doesn't consist in "knowing the right answers" to these questions. Maybe the "right answers" have been given by the instruction process and have been meaningfully learnt by the students. Nevertheless even the most thorough instructional programme is capable of neither eliciting all possible challenging questions about a subject nor transmitting the ability to pose intriguing questions autonomously.

These questions could also be posed and answered without knowing details of the topic; what is demanded is a knowledge of the whole system and of the main relationships among its elements (such as the role of ATP as a chemical energy carrier among catabolism and anabolism in example 1), that is to say a "true" understanding of the main concepts (such as the concepts of chemical substance and element in example 3).

As an attitude towards knowing and knowledge, rather than a body of knowledge, deep understanding should

emerge as a spontaneous recognition of critical aspects, resulting from non-accepting thinking, imaginative processes and the exercise of curiosity. In the second question, for example, the application of inquisitive thinking would consist in posing a searching question on how the strongest acylant of the series could be obtained, rather than accepting the information as it is from the textbook.

A critical extension of this line of reasoning is that a concept map, or other instructional tools used to promote knowledge as guides for "tuning" learner conceptions with universal scientific concepts, are unsuitable and premature for the prompting of those questions that challenge knowledge. Processes of deep understanding cannot be so "patient" that they wait for a complete systematization of subject's knowledge before moving into action. Therefore the processes of critical and imaginative thinking should start working from the very beginning of any approach to new contents. As will be discussed in section 4, a better way to match these requirements could be a controlled immersion in a propositional speech of the new language-discipline.

In sum, deep understanding corresponds to an inquisitive attitude towards knowledge, whereas its opposite is the "accepting" attitude, a mind-set that shouldn't be misunderstood for the "learning by rote". The "accepting learner" doesn't learn mechanically (at least not necessarily), but he/she never thinks that it is his/her place to question the material he/she should assimilate. He/she limits him/herself to trialing and adapting previous conceptions (meaningful learning), or simply to constructing new habits and new responses to the new stimuli involving only the new contents (rote learning). In both cases the "acceptative" learner considers him/herself as an empty vase to be filled, in exactly the same way as his/her teachers do.

Striving for "deep understanding for all", on the other hand, requires the creation of an aptitude, if not a philosophy, of deconstructing – reconstructing in every case, independently of the source, but this skill has intellective-developmental requirements. At the end of his research on the development of meaning, Vygotsky quotes Wertheimer's study in talking about productive thinking (Vygotsky, 1986, p. 205):

«Really productive thought is based on "insight", i.e. instant transfiguration of the field of thought. The problem X that is a subject of our thought must be transferred from the structure A within which it was first apprehended to the entirely different context of structure B, in which alone X could be solved. But to transfer an object or thought from structure A to structure B, one must transcend the given structural bonds, and this, as our studies show, requires shifting to a plane of greater generality, to a concept subsuming and governing both A and B»

This "bridging" from A to B is only possible thanks to a corresponding system of relations of generality. In addition, the inquisitive thinking is essential to run all these processes: thanks to it X is "released" from A, i.e. the structural links connecting X and A are made weaker, and this makes other relations searchable in principle. Inquisitive thinking "searches" for alternative options and alternative structures, among which there is "B". To have a chance of relating problem X to a different sub-system B structural mobility is needed, because the conceptual system "B" – in the problem solving process - doesn't arise by strict logic, ready for use.

Inquisitive thinking, since it is flexible and generative, doesn't demand a forcibly distrustful and suspicious attitude towards information sources. It is, instead, the simple consequence of the authentic and unrestricted exercise of curiosity, in the deepest sense that Dewey referred to the "desire for fullness of experience" (Dewey, 1997, pp. 30-34), as a sort of inward need of harmonization and acquaintance with experience.

Many, if not all, of these habits are a consequence of the systematic development of curiosity, understood as the finest gift of a scientist – researcher. Curiosity empowers the students to tolerate and handle long and rigorous chains of causes and effects that are often necessary to relate two phenomena (such as to link a structural characteristic of a chemical compound to the acidic strength or solubility of the corresponding substance), instead of shortcutting the concept chain on the basis of non-significant associations.

Problem solving furnishes practical contexts where to apply, is a source of curiosity and of concept changing-mobilizing through discoveries of critical issues in knowledge (Thagard 2002, Jonassen 2006), concatenations of causal relations among concepts; the ideal "gym" to develop deep understanding aptitudes.

3 Problem Solving

The desire to achieve these gifts encouraged the extensive "forcing" of collaborative problem- solving in group "A", (see the Introduction). From this experience these conclusions have been drawn.

1. Only a few students felt themselves as competent to manipulate the material and to gather the necessary information, while tackling problems; most of them appeared to act as "secondary beneficiaries" of the resolution process and strategies, or they behaved as mere external or passive observers;
2. Even in circumstances where groups solved the problems autonomously, the process didn't activate metacognition. Students didn't show a clear awareness of having changed their perspective, of having radically changed the formulation of the problem so as to grasp its real nature, of having recognized new relations and concepts, of having discarded unsuccessful strategies. Rather, everything was done and perceived along a linear route leading directly from the premises to the solution, as if they were repeating an already known procedure;
3. Nevertheless, there were some students who were more inquisitive about knowledge by the final grade. That was good, but not enough, because too many learners remained nearly unchanged.

The first point, in the light of Vygotsky's model of development of conceptual thought, can be interpreted as admitting absence of a system of relations of generality (Vygotsky, 1986, p. 205), at least for those students that was called "secondary beneficiaries". For these students knowledge resulted mainly declarative and unsuitable for productive thinking, as to say that the task, also with adult collaboration, was too much demanding, out of the zones of proximal development (Vygotsky, 1986, p.194-5).

The second point, on the other hand, could suggest that even those students who were capable of meaningful learning, and who had developed a systematic framework of scientific concepts, didn't construct habits of enquiry (for problem solving as well as for verbal thinking), as a result of repeated problem solving activities, because this practice was perceived by them as foreign to their role as students, to their styles and aims of learning. This means, in our educational system, the waste of much unused potential in many students.

The action-research operative response was to prepare both – and simultaneously – the conditions for practicing problem posing-solving and a different distribution of the problematic approach to knowledge as a continuous and more affordable - but not exclusive - practice. By systematically disseminating many simple problems, to be solved individually or with the help of the teacher, from the very beginning of the study of the discipline, it could be enough to avoid both nurturing inert knowledge and confirming the standpoint of students who consider themselves as content reproducers. At the same time I argued that problem solving and cognitive conflict are not always enough to prime conceptual change because, as maintained by Jonassen (2006), they need to be mediated by some knowledge-building activities, as outlined in the following section.

4 Concept Texting - Mapping

So that instances of learned knowledge can be effective enough to solve problems, each concept has to be "conceived" as a set of logical and meaningful connections with other concepts: superordinated, subordinated and coordinated, and objects of individual, concrete experience, as part of a system of meanings, rather than as a word that can be remembered only within a sequence of words, as could be a definition learnt by rote. This is what Vygotsky considers as a well developed scientific concept. But this cannot be attained by direct teaching (Vygotsky, 1986, p. 150). On the other hand Vygotsky (1986, p. 192) was aware that «Not even separate concepts as such could exist; their very nature presupposes a system [of meanings]», and consequently: «In the acquisition of scientific concepts the system must be built simultaneously with their development.» For organic chemistry it could be added, among the structures to be built simultaneously, a body of concrete experience with material stuff (substances) and "pseudo-concrete" experience with invisible objects (atoms and molecules), and their symbols (e.g. formulas). In fact this equipment should substitute the tacit apprehension (spontaneous concepts) on everyday life objects which in Vygotsky's theory constitutes an important resource to the "upward way" to scientific concepts[1] .

Under these theoretical and factual pre-conditions, standing the evidences of difficulty to effective use of concept mapping gained from past experiences, resolute in the tenet that not only conceptual thinking is necessary to solve problems, but also, by converse, that real cases and problems are the best pregnancy and cradle of concepts (in oppo-

sition to proposals exclusively based on "verbalisms"), in 2008-2009 – I started to assign enquiring focus questions to be answered - in shared online docs - with short texts (e.g. five lines) by groups of three students. As already pointed out in the Introduction, these assignments were somewhat similar to Cmaps for the propositional structure, limited number and highlighting of concepts in every proposition, and focusing of the knowledge domain upon the question. This writing task, being characterized by higher expressive freedom compared to inexperienced concept mapping, was expected to prepare students to true concept mapping activity. The following is one of the first examples, how it resulted after several hints and changes by peer and teacher reviewing:

Focus Question: What are the characteristics of carbon that allow it to form so many compounds?
Answer + revision (italics): Carbon is a notable element for several reasons. ~~Its different forms include one of the softer (graphite) and one of the harder (diamond) known substances.~~
Deleted because the focus implies a discussion based on the (following) atomic - electronic properties of carbon atoms, not on the physical properties of the substances.
Moreover, carbon has a high affinity for making chemical bonds with other light atoms, including carbon itself, thanks to its small dimensions and tetravalence, arising from the four external electrons that allow it to form strong single or multiple bonds (a property that is called "desmalusogenia" it's the first time I see this word!!!), always reaching a stable octet. Silicon has this property in a very reduced form, because its atoms are larger and the Si-Si bonds are weaker. These properties allow the existence of over ten million carbon compounds.
(Underlined words or groups of words were identified by the students group as concepts, after several revisions.)

Similar concept texting questions were assigned to focus on a) relevant points about the topic to be studied (as in the example), b) specific critical aspects, c) issues to be solved, or d) a hint to further investigation into a topic. The information base materials were the textbook, assigned reading, websites or free research.

The resulting answers (as home assignments) to these questions was often a mixture of text sequences duplicated from the Internet (as happened in the example) or from the textbook, going frequently out of focus; when the sentences were authentically produced by a student, they often needed radical revision or, at any rate, recasting. Even if were given hints or precise reasons for their errors, students were often unable to cope with the assignments by themselves. Once completed, after several revisions with students' contributions, the texts were flimsy recognized as correct, *but rarely the students were observed in making use of meanings that corresponded to the content of the texts*. At the beginning of this trial about the possible employments of similar

writing compositions, I was believing that a sort of straight passage, from the concepts and propositions of the edited answers to a concept map setting, could be possible. But the first results were disappointing: Cmaps weren't influenced by the text formulated by the same students. Singling out of proper concepts from the text resulted a hard task for the students and, above all, useless for the following concept mapping activity. Provided that students hadn't enough familiarity with concept maps and most of the focus questions were actually more specific than the one in the example, concept mapping session about the general topic was postponed after the completion of the textual applications on the same topic. But, once more, the results were unsatisfying.

These findings could be interpreted thanks to a model of meaning change of scientific concepts based on Vygotsky's theory (Vygotsky, 1986, chapter VI, p. 197). Thought processing of new information and ideas (primary product) produces utterances that can be captured as sentences in written language or possibly communicated orally in class (secondary product) - and this increases awareness even if the learner has yet little or no control of the concepts involved. Eventually, the sentences (in verbal thought and in written speech) can be elaborated, changed and combined, repeatedly reformulated in different contexts under adult expert collaboration and control, to attain enough consciousness to be able to autonomously produce acceptable propositions (tertiary product). This three-step process form just the first stage in the "race" to consciousness and control of meaning. Without control it would be very hard to seek a flexible conceptual organization as in a concept maps (quaternary products). Now, in the light of this route of scientific concepts development, we conclude that most often the learners stopped at the first stage (strictly individual) of arbitrarily transforming thought into a textual production, without any reinforce from the social context. We shouldn't be surprised if concepts and conceptual organization didn't emerge from this spontaneous written language,

[1]The building up of this latter should be indeed a well rooted task in the first period of secondary school science education, but actually the majority of older students cannot rely on it.

nor if the words in it weren't applied properly in concept maps. Finished text compositions were not at all representative of the actual level of understanding of the students. Moreover, in December 2009, by close observation of the results of a class-work in class "C", I was triggered to realize the phenomena of "lacking words" (see Introduction) in all interpersonal students' explanations-communications as for oral reports and written class notes.

These points became clearer and clearer as I went through the experiments until, finally, I decided that textual assignments should have been given a different format and scope, more focussed on speech facilitation[2] . These tasks can be accomplished by describing a known transformation, a molecular structure or its properties, or by decoding some symbolic information into words and vice versa[3] .

Here follow some examples of speech facilitation assignments:

1. Write a sentence that explains how ammonia can be transformed into ammonium ions, using these terms: proton, conjugated acid.

2. Describe what happens in this transformation, using appropriate terminology



3. Hydrogen bromide protonates 1,3-butadiene in its C1 carbon, generating a secondary carbocation. Write down a complete scheme for this transformation.

4. Describe in detail the mechanism of aspirin synthesis from salicylic acid and - as an acylant – acetyl chloride instead of acetic anhydride.

5. Describe in detail the arrow-movements of electron couples that lead the base structure of imidazole to other resonance limit structures.

Writing and reading in class, decoding symbols and encoding words in symbols, imply that objects are labelled and rehearsed by their words, a bottom-up task that gradually transforms these words into precise meanings. Problem solving implies a very different task, somewhat reversed: from a generalisation of the problem (bottom-up) to the selection of necessary meanings or concepts (top-down). The awareness that a concept is necessary to deal with a problem, always expands its meaning and makes it more accurate. Hence some queries are not purely linguistic, as in the following examples which contain a simple problem in addition to the textual assignment (anyway, problem requests are easily distinguishable from textual demands):

6. An unsaturated hydrocarbon C4H6 doesn't react with sodium amide. But, when it reacts with hydrogen and Lindlar catalyst it yields an alkene. Describe with words and schematize the reaction occurring to the hydrocarbon with dihydrogen.

7. An enole having four carbon atoms transforms spontaneously into an aldehyde. Find a possible enol structure and describe the transformation only by means of words.

This kind of speech facilitation work strategy was applied intensively, both orally and by writing, in the period January-April 2010, in class and in personal online portfolios called "Student's knowledge building yard" shared documents, especially in group C (see introduction), where the results were more encouraging, in terms of problem solving skill and conceptual mastery in independent assessments trials, for those students who applied significantly. The purpose of these activity is to permit a sort of jargon's learning by imitation, with a progressive increase of

[2] Also the correct way to pass from concept texting to concept mapping gained a new planning, as we'll see at the end of this paragraph.

[3] The latter is a particularly relevant work, because students are prone to manipulate, to add or to transform symbols, without associating them with the respective words, thus binding their usage to experience and appearance only. Even if their symbolic "mute" manipulations can be viewed as logical (by the students and the teacher), they don't make any sense of them. This hinders any chance of making any generalizations and of exporting the related concepts raising from the immediate experience. The success that students sometimes report, thanks to these rote manipulations (this would be a consequence of assessments that verify mechanical ability to reproduce actions and contents), ultimately takes them further away from verbal and conceptual thought.

consciousness until the students will be able to act autonomously. An intention for the future is to introduce similar written speech activities where disciplinary jargon will be analogously played to set up reasoning clusters by imitation (explaining instead of just describing).

However, first of progressing with other developments, it is important to pause on a further important aspect that theoretically supports the speech facilitation strategy for knowledge building.

When Vygotsky (1986, p.197) tell us that single concepts couldn't exist if not being part of a system of meanings, he refers only to the upward way to scientific concepts. But there is indeed another reason that is clearly pointed out by Jonassen (2006)[4] and that, on the other hand, is perfectly compatible with the distinction among "meaning", and "sense" outlined by Vygotsky in the transition from external to inner speech (Vygotsky, 1986, Thought and Word, pp. 244-5)[5] :

«The sense of a word […], is the sum of all the psychological events aroused in our consciousness by the word… Meaning is only one of the zones of sense, the most stable and precise zone. A word acquires its sense from the context in which it appears; in different contexts, it changes its sense. Meaning remains stable throughout the change of sense.»

This quote confirms that the system of concepts and its stable relations among meanings (as could be a concept map or a glossary) would never be sufficient to recreate the body of tacit consciousness that give us a grasp on the real world; and suggests that a rich assortment of different contexts, where to "play" pattern of words, concepts-in-use (Jonassen, 2006) from the "speakers dictionary" - in the speech facilitation task - should be the privileged route to interiorize those not-writable rules of the language game (Wittgensten, quoted in Jonassen).

These issues, by the way, support the idea that the processes of meaningful learning of an almost completely abstract subjects (as organic chemistry) sums up the developments of mother language, mainly by immersion, and of a second language, provided that upward shift of meaning (as subsuming cases into grammar or conversation rules) and downward formation of tacit sense (e.g. getting used to idiomatic phrases and contextual-colloquial expressions) are both strictly needful.

Another recently experimented writing task (in group C) was summary composition. From the first results I realized that this task could be more useful if assigned (in the quick form) as soon as a certain topic or sub-topic was outlined, rather than at the end of its course. In fact such summaries permitted also to observe inclusive concepts' organization, when these structures were still fluid and it was possible to set out a correction.

Students had between 15 minutes (to prepare the discussion in fifty-minute's classes) and half an hour (as part of final classworks including exercises and problems too) to write down a detailed and complete essay about a particular segment of study. Texts about a class of reactions, in the half an hour summary, were between 100 and 500 words with 20-40 words per sentence (the highest number of words was used to explain reaction mechanisms). I derived concept maps from some representative students' texts (those texts with the higher variety of frequent errors, or with interesting and original organization), with the dual purpose of introducing concept maps and discussing students' work (see e.g. Figure1). I was surprised by how was easy to converted the students' text compositions into Cmaps, without loss of detail, but with a neat simplification in text structure, making the conceptual organization clearer, effective and useful to discuss the most common errors. Many compositions showed relevant faults in the organization of superordinate, top level concepts. These errors were very recurrent, even though they obviously weren't in the Cmaps that I had previously prepared and presented as preliminary guides or as surveys for final topic synthesis. This kind of error in categorization showed that a prolonged focus by students on a specific sub-topic improved the understanding of that topic, but, at the same time, altered the understanding of the sub-topic's role in the general structure. From the written compositions other misconceptions and gaps also emerged.

[4] Jonassen reports from Wittgenstein: «concepts become meaningful in their rule-governed use in language. The rules that govern their uses are called language games, which govern the acceptable uses of words.»

[5] See also Vygotsky's concepts of "first child's word as a whole sentence meaning" (1986, p. 219), "tendency toward predication of inner speech" (p. 236, p. 243), "agglutination of words in a sense" or "influx of sense as flowing of sense from a word into another" (ibid., p. 246).

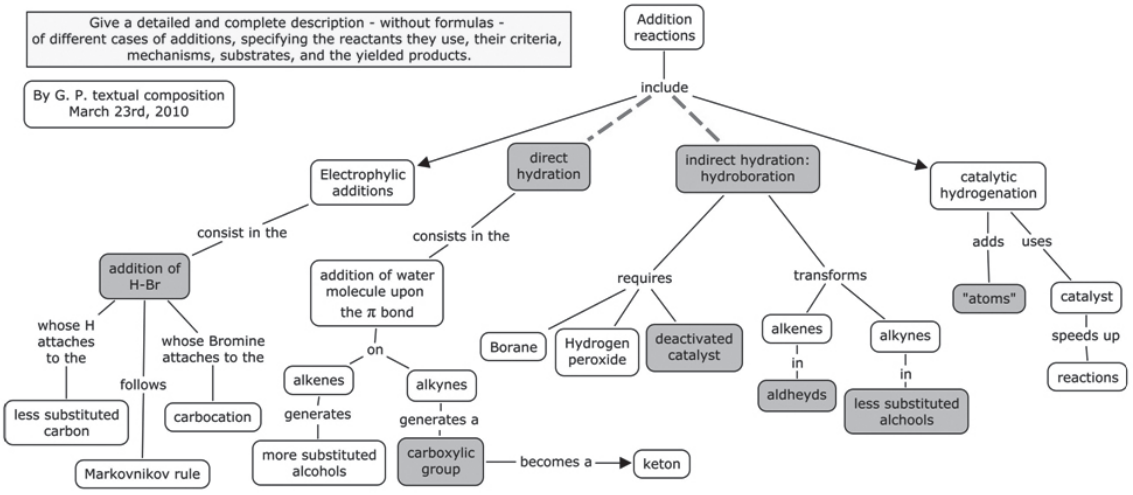


Figure 1. The text by G.P. transformed in Cmap. Two types of hydration reactions (sub-types of Electrophylic additions, dashed connection lines) have been considered as having the same rank (i.e. of a different nature) of Electrophylic additions, besides a series of errors (in gray)

Written texts presented a higher rate of complexity and revision which could not have been matched by rigidly connected Cmap structures even in longer class time (the expert cmapper is actually the one who is able to revise the blocks in a Cmap substantially and quickly, with the help of suitable software). Nevertheless, I decided that moving towards concept maps had been important because:

1. Skilfully constructing Cmaps (taking a comparable amount of time to that for textual composition) would enhance self-criticism and metacognition.
2. The opportunities for comparison and sharing of ideas enhance inter- and intra-group criticism, while paper textual summary essays provided less scope for interaction, especially during their construction.
3. In concept mapping the organization task is more relevant than in writing short-medium length texts. Students pay more attention to the organization of the most inclusive levels of a Cmap than they do in a normal text, avoiding the observed "unbalancing" effect[6].

Moreover, I foreseen a possible strategy to carry students to become concept mappers along these three stages (already applied up to the begining of the second stage, in group "C", until the school year term):

First stage. Once a short text composition has been worked out by the students, some of their most representative texts are transformed into Cmaps by the teacher in front of the class. The teacher express first the fundamental criteria for concept mapping, as the students engage with the vision of the growing Cmap and of the original text written by their peers, side by side. As soon as the Cmap has been completed, the teacher will open a critical session about the meanings that are implied by the Cmap. Apart from the obvious conceptual task, this approach will help the students to identify themselves as Cmappers and begin to prepare them for the imitation of criteria for good concept mapping (see, for example, Figure 2).

Second stage. The students write down a very short text composition on a simple topic (10-15 minutes) and then encode it as Cmap. In this case they may be free to make changes, provided these will be highlighted in the Cmap. Then, the teacher will open a critical discussion as in the 1st stage, based only on the Cmaps, and will leave the checking of the agreement between text and Cmaps to later. This will give the opportunity for meta-cognition involved in the transformation of text to a Cmap in a subsequent class. This experience should be repeated until every student is able to faithfully transform a text into a Cmap.

Third Stage. Students write their "essay" straightaway in the form of a Cmap. Some of the students' Cmaps un-

[6]Moreover, the scaffolding structure of general concepts can be easily transferred in "daughter" Cmaps about different sub-topics, while understanding of the main structure should remain stable even if those sub-topics will be slowly developed and/or enhanced in time.

dergo oral verbalization (without criticism), and then a "mean quality" Cmap is chosen to be revised and optimized collaboratively by the whole class. Every student should decode that common Cmap as a text and add the personalized essay-text to his/her portfolio. This final stage could remain as a consolidated habit in the development of the conclusive part of every topic (e.g. weekly). The task of selecting a mean Cmap to revise collaboratively could be assigned to different cooperative groups, offering a further possibility of comparison and discussion of the group-Cmaps.

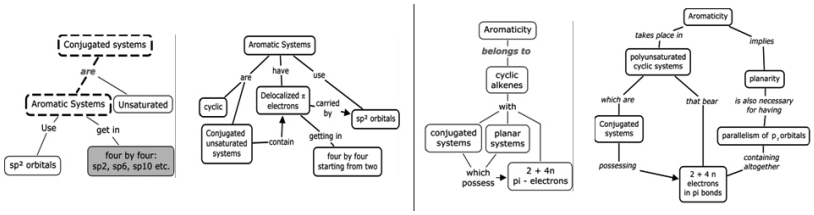


Figure 2. Examples of first stage development in passing from concept texting to concept mapping (April, 2010). First and third are Cmaps converted from students' texts (by L.F. and V.V.) answering the question: "Which criteria should be satisfied by a hydrocarbon to be an aromatic one, and which properties will be distinctive of it?" Second and fourth Cmaps are as they appeared after critical discussion in class

5 Conclusions

A lot of work needs yet to be done in order to understand how to improve true concept changing, i.e. how to make those changes that result from critical discussion in the class socio-cultural context (as the changes shown in Fig. 2), correspond to true metacognition and to actual changes of the structure of meaning, at least for the students more directly engaged in the discussion.

A recent research of Hilbert and Renkl (2008) has indicated that worst learner «had significantly worse verbal abilities than learners in the cluster with the best learning outcome», confirming that the "concept texting" tasks outlined in the previous paragraph, but also a generalised improved methodology in relating learning to written verbal language in all disciplines (even in mathematics!) are a pre-condition for successful application in concept mapping and for its effectiveness as a tool for learning mediation. The preference for written text in the initial speech mediation is also grounded in Vygotsky's research (1986, pp.180-182):

«Written speech is considerably more conscious, and it is produced more deliberately than oral speech... Even its minimal development requires a high level of abstraction… Written language compels the child to act in a more intellectual way»

The mastery of meanings and senses of a disciplinary speech and lexicon is, in turn, an evident precondition for successful problem solving and any kind of productive thought, as the ones entailed in deep understanding. So we can agree to a golden rule for linguistic facilitation as:

If you want your students to assimilate a new concept, assure yourself that they have first faced a sound written speech task about the group of related concepts.

6 Acknowledgments

I'm grateful to Sok Khim, one of his paper's reviewers, for his important suggestions, and I apologize to him for not having been able to insert and discuss more organic chemistry examples (anyway, interested readers can find other applications and examples from www.divini.net/chimica or writing to the author), and I acknowledge a special merit to Manuel Aguilar-Tamayo for his precious guide in the Vygotsky's universe.

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THE TYPES OF CONCEPTS STUDENTS PREFER TO ADD TO INCOMPLETE CONCEPT MAPS

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Abstract. The main goal of this study was to explore different potential components of science and technological literacy. The study explores student's skill of grouping concepts and creating a concept map. The sample for the study consisted of 131 grade 11 secondary school students from all over Estonia. A test comprising 2 problems was compiled to investigate the grouping of alcohol related concept and creating a concept map. Findings from the study, showed that students mostly make subject related groups and they don't see relationships between different types of terms. To create a concept map students added mostly social and value related terms, students avoids subject related terms If students have a possibility to avoid social factors, then they don't use them. Only students who have good problem solving skill (good STL skill), can associate subject content to social factors and also show how different subject content were related.

1 Introduction

It is widely assumed that science education needs to promote students' scientific and technological literacy (STL). It is not clear from the literature what STL actually is, but many authors have considered its impact on the goals of teaching. (OECD/PISA, 2003; Holbrook & Rannikmäe, 1997; Bybee, 1997; AAAS, 1989; NRC, 1996). NSTA in its statement on the attributes of a scientifically and technologically literate person (NSTA, 1981) recognised that content was not a key factor and that intellectual development, personal development, social considerations and interdisciplinary learning were important attributes.

One component important for the teaching of science based on an STL philosophy is the development of problem solving and critical thinking abilities in students. It is recognized that this requires a conceptual base related to the problem to be solved, or the critical situation being investigated. Developing problem solving abilities in a non-meaningful context means that students are also required to transfer their problem solving skills to context in which they which to carry out 'real' problem solving. This has been shown to be difficult for students and saw the abandonment of a project –Science – A Process Approach (where the processes were thigh in isolating from a real science context) being abandoned. To achieve good STL we need larger goals in science education then just good subject knowledge. Bybee (1993) clarified the structure of science education in terms of five major components:

a) Empirical knowledge of physical and biological system;
b) Scientific methods of investigation;
c) Personal development of the students;
d) Social development, or achieving the aspirations of society;
e) Career awareness.

Solomon & Aikenhead (1994) went further and showed that besides a structure for science education it was necessary to elaborate the personal developments and suggested these as consisting of attitudes, problem solving skills, critical thinking ability, as well as exhibiting creativity. And behind these abilities are others skills such as grouping and finding relationships between concepts. How we can find relationships between different types of terms shows that how good is thinking order skill. One way to improve students thinking is to use concept maps. Like Hsu (2004) said 'Concept mapping can promote students problem-solving and critical thinking to help students organize complex patient data, process complex relationships and offer holistic care to patient'. Also concept mapping requires a students to sort out and present data in a way that is logical, orderly and unambiguous (Wilkes et al. 1999). Its shows that students need to know concepts and relationships between them to achieve high level thinking. Even more, just memorizing concepts isn't enough, because to use concepts it is necessary to acquire a meaning for such concepts and how they are related to other concepts. 'Just rote learning isn't effective; you need to use meaningful learning' (Novak, 2002).

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Concept mapping has been put forward as an easy way to encourage very high levels of cognitive performance (Novak, 2002), and when the process is done well, it illustrates one reason why concept mapping can be used as an evaluation tool (Edmondson, 2000) and can use d to measure the structure and organization of an individual's knowledge (Novak and Gowin, 1984; Ruiz-Primo & Shavelson, 1996). A concepts map presents a person's knowledge about a certain concept or subject (Zele, 2004). Every concept in a concept map can be linked with many different concepts (cross-linking) although it is not suggested that all concepts are linked with each other; only the prominent and most useful cross-linkages need be identified. This process involves what Bloom (1956) identified as high levels of cognitive performance, namely evaluation and synthesis of knowledge.

This study investigates how students group concepts and find relationships influenced by teaching related to the development of intellectual skills in a social environment based on an STL model of science education, where subject conceptual learning is grouped with an appreciation of the applicability of science in understanding everyday life and science playing an important role in the decision making related to socio-scientific issues (Kolstø, 2006). In particular the study considers how far students relate concepts, linked to alcohol, to the conceptual understanding associated with academic chemistry, as well as to concepts related to the uses or misuse of alcohol in everyday life (referred to in this study as technological concepts) and to problems or issues in which the chemistry conceptual knowledge plays a role in the decision making process in everyday life (social concepts). The study explicitly examines how students group different alcohol-related chemistry concepts through trying to complete a partially developed concepts map and examining the relationships they make. To illustrate the difference between the groupings and to find relations, the study also explores:

- what type of groups students make;
- how much students see relationships between different type of concepts (how much the include linked groups):
- what concepts students add to existing concept maps;
- the number of different (chemistry, technological, social) concepts and the relationships they add;

2 Methods and Sample

The sample for the study consisted of 131 grade 4 secondary school students from all over Estonia. The sample was formed from students whose teachers participated in an interdisciplinary in-service course (Interdisciplinary teaching for science courses: Interesting problems from everyday life and they scientific explanation) and who expressed an interest in STL. Respondents were from different schools – small country schools, big city schools, schools where students undertake advanced science studies. All students had completed their study of inorganic chemistry and had begun studying organic chemistry in grade 11. By the time they took part in the study they had already studied hydrocarbons, alcohols, aldehydes and carboxylic acids. It was thus assumed these students had all the necessary knowledge to solve the problems. The profiles of the teachers who taught these students were different. Some had more than 35 years of school experience, whereas others had only two-three years of school experience.

The data for the present study were collected using a test compiled by the authors to investigate student's skill of grouping and making concepts map skill. The test consisted of two problems. The first problem tested student's empirical knowledge. In this problem, students were asked to group subject content (related to alcohol) and to give reasons why they formed such groups. Of interest was to know how (and why) students grouped different concepts and what type of groups students created. Did students use only similar groupings (for example: ethanol, methanol, ethanal are organic compound or oxidation, alcohol dehydrogenase, vaporization are processes/reactions in chemistry) when placing concepts into the same group, or did students create groups where different concepts related to linked groups (for example: ethanol, oxidation, ethanal, ethanoic acid, enzymes; all words relate to alcohol oxidation in the human body).

Problem two examined interdisciplinary skills related to how students find relationships between subject content and social factors and asked students to add different concepts/words to an existing concept map, plus show relationships between the concepts added. Also studied were the numbers of relationships students form per concept. The initial concept map gave different types of concepts. Some concepts related to the subject, some to technological processes used in everyday life and others to societal problems or issues. The concepts were at different levels, some were considered key, while others were minor and not necessarily found in all textbooks. As Krajcik (1991) said 'understanding other subject content depends on students developing an integrated understanding of basic concepts'. In this part of the test, the truth of Kracjik's assertion was investigated, but in addition social factors were added to further determine students' interdisciplinary skills. This problem showed us what type of concepts students add to concept map and how many different relationships they can do.

The completed test was validated before the collection of data by the teachers who participated in the interdisciplinary course (35 science teachers) and also by 65 11th grade students. This was carried out by a small pilot study, in which one class of students were given the two questions, to ensure the questions were understood and the students were able to work individually in giving meaningful answers to the questions in a reasonable time period. It was concluded that the test had appropriate construct validity and the tasks required were well understood by the students.

3 Results and Discussion

Outcomes from the questions were considered by determining the number of subject groups formed, the number of technological groups in which students relate to concepts from everyday life and the number of linked groups which illustrate student ability to link concepts across the academic and technological concept domains. If students see relationships between such different domains, i.e. they illustrate more linked groups, the students are perceived to have high levels of thinking based on Bloom's taxonomy (1956).

Results from question 1

Student's answers from problem 1 can be categorised into four different groups. The first group is made up of similar groups, where the same type, subject related, concepts (like methanol, ethanol, aldehyde or oxidation, alcohol dehydrogenize, burning) are put together. The second group consists of technology related groups, where mostly concepts related to the breathalyzer and analyses based on this are included. The third group consists of linked concepts, where processes and related concepts are linked (such as alcohol, alcohol dehydrogenize, aldeyde). The fourth group was a no meaning group where students did not give any relationships between concepts.

The results from problem 1 (Table 1) showed that students mostly used similar grouping (same type of words in one group); only 30% groups, created by students, were through the use of linked groups. The result showed that students could group the same type of terms, but they were far less likely to use relationships between dissimilar terms. Where students did include linked groups, most (70%) related this to analyzing alcohol in the blood. Only a few students using linked groups which were purely chemistry (for example: ethanol, oxidation, aldehyde, temperature – alcohol can oxidized to aldehyde and the speed of that process is related to temperature.) The outcome showed that students were familiar with the breathalyzer showing alcohol breath content and from this calculating the alcohol content in blood.

In problem 1, students also needed to group all terms. Approximately 70% students didn't use all terms; also most of them didn't write why all terms were not used. Some students formulating another group indicated "I don't know these terms". In general, 34% students didn't make linked groups at all and 35% students did so using only subject related groups.

School nr	Similar subject groups (% from all groups)	Technological group (% from all groups)	Linked groups (% from all groups)	No meaning groups (% from all groups)	TOTAL % (subject + technological + linked)	Unused terms (% from all terms)
1	56	14	28	2	100	21
2	59	14	22	5	100	18
3	40	8	36	16	100	39
4	45	9	29	17	100	30
Average	50	11	30	9	100	28

Table 1. Types of concepts groups formed by students (as a % of all groups formed)

Table 2 shows that approximately 70% students, on average, did not use all terms. Mostly the unplaced terms were: temperature, indicator, analyze diffusion and alcohol dehydrogenize. Reasons for this may be that students did not understand sufficiently the meaning of the term, or how that term related to other terms.

Nr	Subj. (S)	Techn. (T)	Linked (L)	S+T	S+L	T+L	S+T+L	Unused Terms
1	83	47	57	43	43	7	7	73
2	93	43	67	43	60	17	17	63
3	48	23	60	20	23	3	3	73
4	45	7	34	19	39	6	6	68
Average	70	32	61	34	40	8	8	69

Table 2. Percentage of students creating the different types of groups per school (shown as % of total students per school)

From Table 3, we can see that subject groups were mainly composed of 3 to 4 terms (26% and 23%). But 16% students created groups using only two terms, even though it is not usual to consider two nouns as a group. If we add these groups to the percentage to unused terms, the percentage of unused terms increases substantially. In forming the technological groups, students mostly found using three nouns per group, the easiest. On the other hand, linked groups were mostly formed from five terms, with the range mainly from 4 to 7 terms. To link many different types of terms into the same linked group needed high order thinking skills and not all students were able to exhibit this.

Nouns	Subject (S)	Technology (T)	Linked (L)
2	16	11	1
3	26	35	12
4	23	14	20
5	13	14	24
6	11	8	15
7	4	14	20
8+	6	5	7

Table 3. Percentage of groups (as % of total groups for that category) created with the indicated number of nouns

From problem 1, results show that student's responses can be combined into four types of groups with students mostly giving similar groups. Generally, students don't give relationships between different types of terms and only a small percentage of groups were linked groups. This would suggest a possible lack of higher order thinking among the students. Also, the number of terms in each group was generally low, further suggesting a lack of higher order thinking. If students have high order thinking then they able to transfer their thinking to new situations and see relationships between many different terms (Hsu, 2004).

Results from question 2

Students answers to problem two were also categorised into four groups. The first group was science concepts, mainly chemistry concepts but also integrated concepts, where chemistry was related to biology or physics. The second group was technological concepts, where students added concepts related to technology, mainly the breathalyzer. The third group was social related concepts, affecting people in their everyday life and the fourth group is value related concepts, affecting the individual in society. The existing, partially completed concepts map included examples of all four different possibilities and allowed ample opportunities to add concepts in each group. This contrasted with problem 1, where only subject related terms were given.

Results from the second problem showed that more than half (60%) of the additional concepts were related to social factors. Students were able to change a concept map by adding social factors if asked to do so; only a small percentage of students (10%) used chemistry content to complete the map. Some students (16%) also used integrated content (chemistry, physics, biology) to complete the map, but almost all students (92%) didn't add technological concepts and presumably did not see technological relationships.

School	Group 1 Science	Group 2 Technological	Group 3 Social	Group 4 Values
1	17	8	50	25
2	16	8	52	24
3	14	7	53	25
4	18	9	51	24
Total	16	8	52	24

Table 4. Percentage breakdown of concepts added by students in groups 1-4 (as a % of all concepts added)

Table 4 shows that more then 50% concepts (52%) which students added were socially related concepts and 24% concepts were value related. The number of science and technological related concepts was low (science 16% and technological 8%). A possible reason for this is that students find it easier to add social and value concepts. They know more about social life and adding concept to that part is clearer to them.

Figure 1 combines all students' answers into the same concept map. It shows that 75% concepts are social, or value related. In the science, part there are only three different concept types, one related to burning, another to other alcohols and the last to poisoning. The technological group illustrates only one concept type – that related to measuring alcohol blood content by using a breathalyzer. By contrast, in the social part, students added five types - the first related to hospitals and car accidents, a second to criminal conviction, a third to addiction by alcohol, a fourth to being drunk and getting a hang-over and a final type to alcoholic drinks or alcohol like drugs, solvents, etc. For the value types, students added different types of diseases which may be caused by alcohol and the consequences deriving from the use of alcohol such as unsocial people.

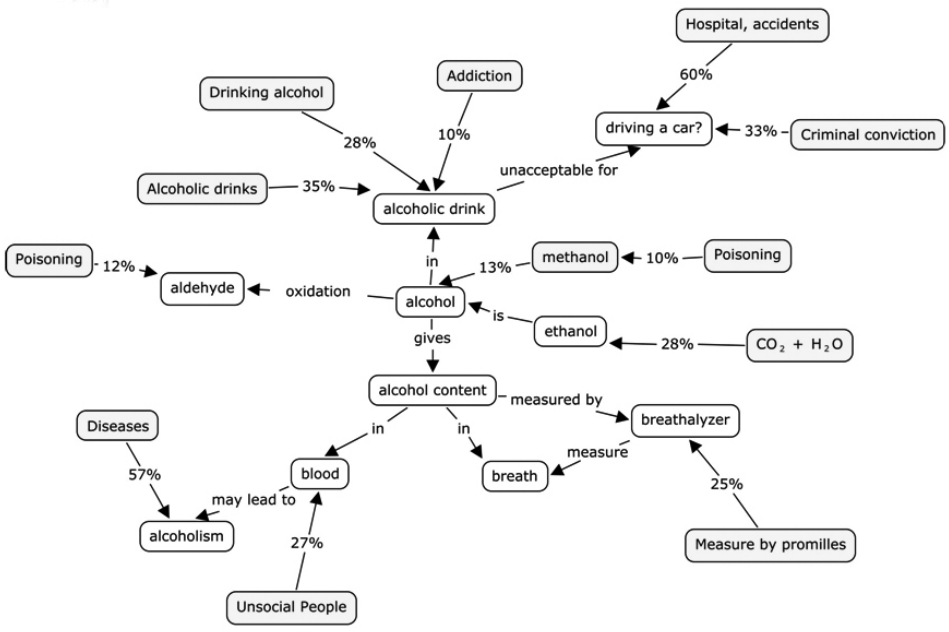


Figure 1. Typical concept types (percent of students who created this type of concepts)

Figure 2 shows an example of one concept map created by students. It shows typical concepts, although not all students added so many different types of concepts. The scheme shows nicely that students added more concepts to the social part. In general; students did not include scientific concepts if they had the opportunity to use social, or value related concepts.

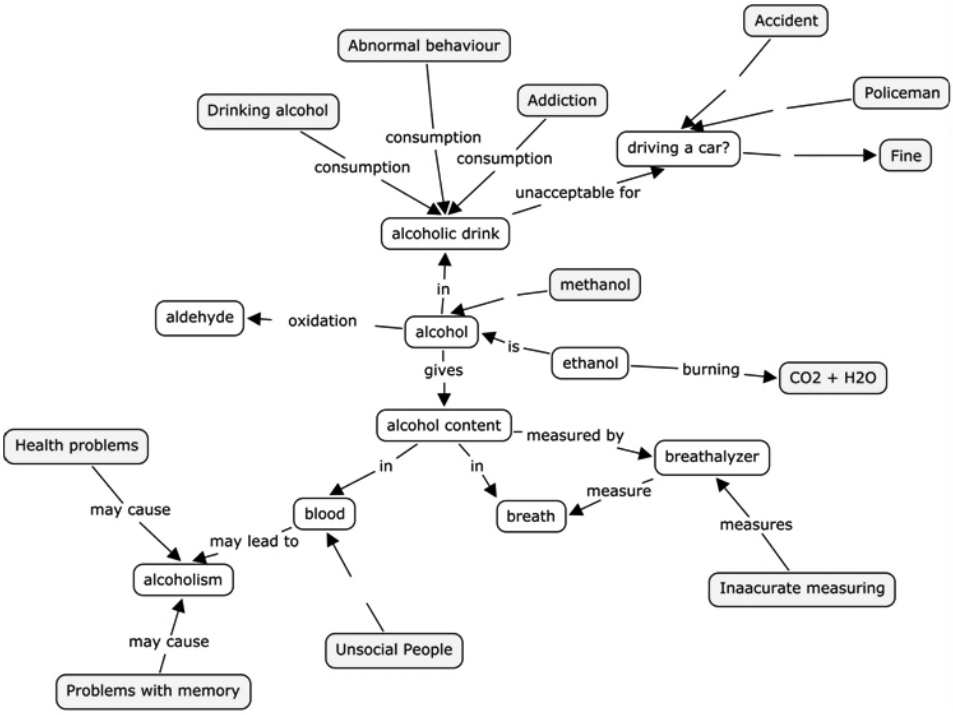


Figure 2. Typical student concept map

4 Conclusion

In the first problem students answers can be categorised in four different types. Students created more similar groups than linked groups and did not see relationships between processes and related terms. Only a small percentage of students formed linked groups.

In general, when students were faced with an incomplete concept map as was the case to answer the second problem, students didn't use scientific content to enlarge the concept map. They using mostly social and value related terms, illustrating student's tendency to avoid the use of scientific context and use other contexts such as social. Students probably found it easier to add concepts to social related terms, because it is related to everyday life and like some papers show students are interested in aspects relevant to them such as alcohol and alcohol related phenomena (Teppo & Rannikmäe 2003; Osborne & Collins 2001).

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THE USE OF CMAPS IN THE DESCRIPTION OF CLINICAL INFORMATION STRUCTURE AND LOGIC

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Abstract. The development and implementation of competent and cost-effective computerized medical records will require the development of a new paradigm for the representation and analysis of medical knowledge and logic. Medical knowledge is acquired inductively by observing, measuring, and eliciting information from patients in a process that is investigational rather than transactional. Most, if not all, current approaches to health information technology (HIT) rely on a logic and data structure that imposes significant limitations on the ability of physicians to adequately and efficiently document and access empiric patient data because the information is almost invariably organized deductively and lexically which presumes, rather than makes explicit, the relationships of concepts and their meaning. Cmapping provides a graphical method of capturing and displaying expert content knowledge which is simple to comprehend and modify, and provides a foundation for a dynamic, inductive, and inclusive method of clinical documentation and research. The basis of medical decision analysis along with representative samples of medical knowledge modeling in the Cmap format is presented.

1 Introduction

The basic science and clinical foundations of modern medicine are evolving so rapidly and broadly that the capture, access and use of this vast amount of data advantageously and efficiently has generated a world-wide challenge to effectively use modern health information technology (HIT) to improve the health of the world's citizens. The United States government has recently embarked on an unprecedented program to convert the current US medical system, in which less than 10% of clinical practices are using electronic medical records, to a universal, interoperable, clinically meaningful electronic system by 2015. This has been mandated in the context of the extremely rapid and virtually universal adoption of computerized practice management systems in the United States in the past two decades.

It has been widely assumed that such systems 1) would be developed as elaborations of currently existing clinical computer technology; 2) could be modeled on current specialized systems, such as radiology and emergency medicine HIT, for other specialties, such as ophthalmology and dermatology; and, 3) that there would be significant improvements in safety, quality, and efficiency, that would rapidly lead to lower healthcare costs. These assumptions have not been scientifically demonstrated, may not be valid, and the failure to take these possibilities into consideration may lead to qualitative and fiscal degradation of healthcare. Despite the obvious incentives and the example of successful implementations in several specialties, there has been widespread reluctance and uncertainty about its general adoption by most medical practitioners, if not by administrators, politicians, public advocates, etc.

Physicians have widely adopted costly and complex new diagnostic and therapeutic instruments. They have been willing to undertake extensive continuing medical education to learn newer and better techniques of patient care. Most physicians will use tools that they find are consistent with or can be adapted to their personal approach to patient care and practice management. It is our premise that the structure of current HIT is inconsistent with the core of clinical medicine and that this inconsistency has motivated the inertia that has resulted in slow and limited adoption of HIT for clinical documentation.

We have experimented with Cmapping and have concluded that it is a useful tool for the capture of expert knowledge in a way that lays the foundation for further advances in the development of information technology that will improve the access, quality, and safety of medical care. We believe that such systems should enhance physician and other provider productivity and effectiveness, in order to lower costs. Such a system should also provide a foundation for new approaches to research of large and diverse populations, across cultural and linguistic boundaries. In

addition, the system could also encourage better patient counseling, since many of the Cmaps can be used by patients to better understand their conditions and treatments.

2 Clinical Data Structure and Logic

Cmaps are particularly useful for content experts to collaboratively describe clinical findings to essentially any level of detail. It is possible to annotate concepts with textual and image-based references. It is important in clinical documentation systems based on a detailed clinical knowledge model not to blend empiric evidence with inference or diagnosis, but to express evidence and inferences using a common terminology that is semantically consistent. Physicians may wish to describe the physical findings, capture patient history, and make measurements with instruments that are properly calibrated or standardized. Each observation, measurement, sign or symptom must be captured and described at whatever level of specificity is known or relevant. Evidence must be able to be represented at the desired detail.

Blood pressure measurement seems to be a simple piece of data to capture. In most situations, the patient's identifying information is connected to the diastolic and systolic measurements, as illustrated in Figure 1.

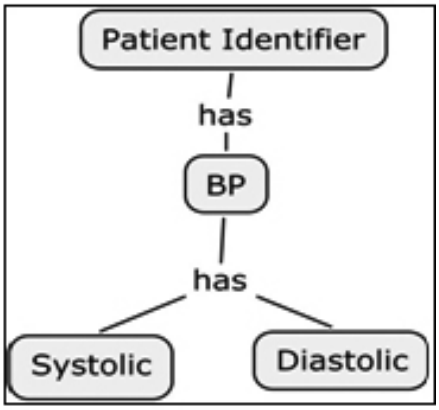


Figure 1. Simple Blood Pressure Description Model

There are times that such a representation of blood pressure is incomplete and insufficient, particularly in critical clinical situations, such as in intensive care or surgery. Although not exhaustive, Figure 2 illustrates a greater level of complexity that may be required to document a not-so-simple blood pressure.

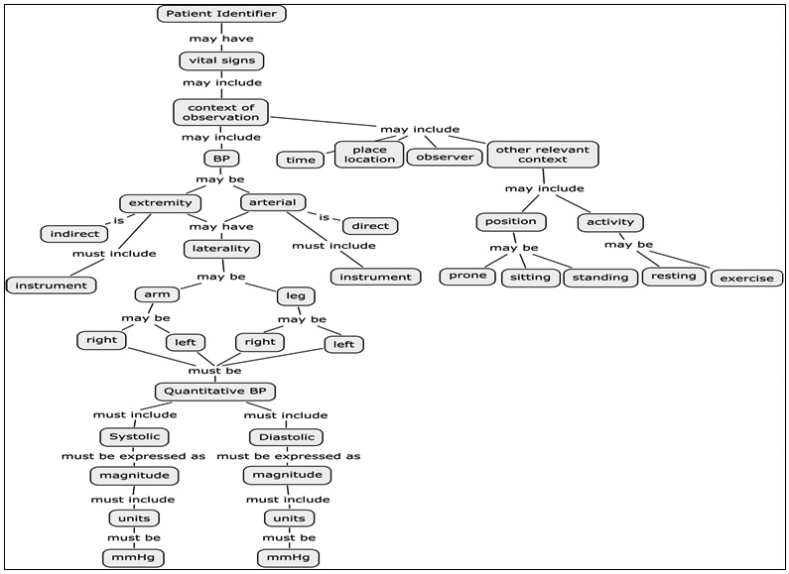


Figure 2. Complex Blood Pressure Description Model

In the context of a paper record, one would record the particular details that modify and contextualize the finding. In an electronic medical record, however, the functionality to capture that detail must pre-exist or the data may be recorded without the requisite modifiers.

Clinical findings may require reinterpretation over months to years by the same or new providers. Descriptive functions have historically tended to be idiosyncratic and personal because they represented notes intended to jog memory at a future time. These personalized documentation systems may not be easily interpreted by others. It is often unfamiliarity with the descriptive meaning that prevents rapid interpretation of older or unfamiliar records rather than the infamous "bad handwriting" of doctors. Having practiced medicine for 30+ years, the author has learned to decipher clinical notes from the past. The major barrier to understanding the implications or meaning of a predecessor's clinical note is much less the decryption of the words themselves – the lexical content – but rather the difficulty is interpreting, accurately, the clinical intent or the semantics of the record.

The traditional medical decision cycle is a specific example of a general decision cycle description as formulated by Boyd in the 1960s and 1970s, which is known as the Boyd Cycle or OODA Loop. (Figure 3) The relevance of Boyd's Observation-Orientation-Decision-Action cycle to medicine is easier to understand when applied to every aspect of medical decision making – from the slow-motion management of neuro-degenerative disease to intra-ocular microsurgery. Cycle time can be a critical element in medical outcomes, particularly if physician decision making lags behind the disease process or anatomical complexity of the surgical field.

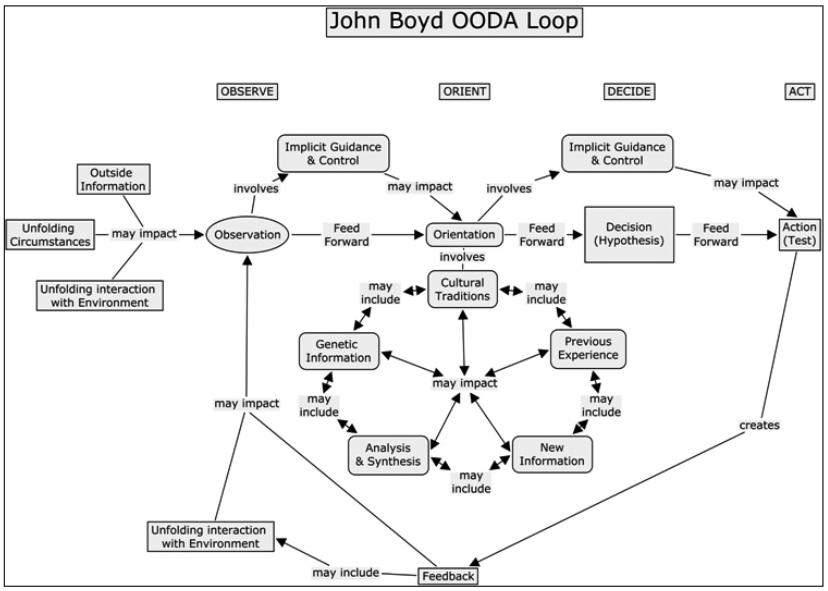


Figure 3. OODA Loop

The fundamental requirement of any clinical documentation system, written or electronic, is preservation for subsequent use of information that informs the evolution of the clinical decision cycle. This cycle is characterized by a process of examination, diagnosis, prognosis, and treatment. (See Figure 4) Examination is composed of the collection of empiric data in a process that is affected by cultural, environmental, scientific and other factors.

Then, considering such elements as the training and experience of the physician, the availability of particular diagnostic modalities, etc., a diagnosis is arrived at, which is a provisional explanation of the empiric findings. A prognosis is the element of the medical decision cycle that represents the clinician's expectations for the on-going health state of the patient. Temporal, symptomatic, physiologic, etc. hypotheses may be articulated at this time. Therapy is the action that may be taken to intervene in the progress of the patient's condition. The cycle continuously repeats until some conclusive endpoint is reached.

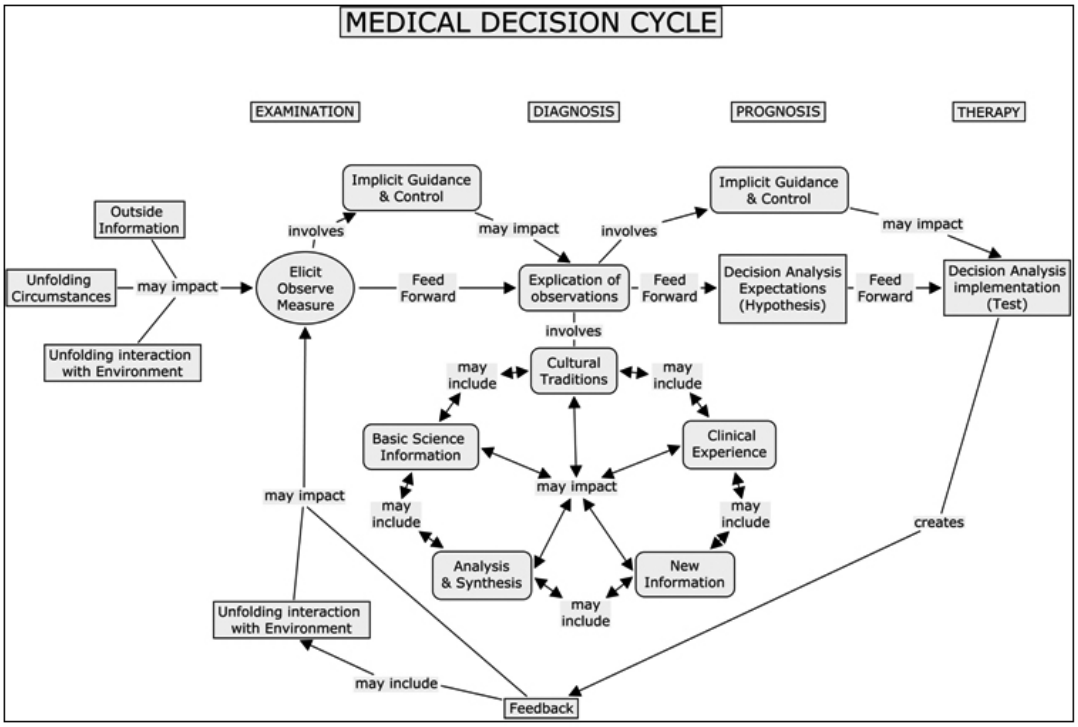


Figure 4. Medical Decision Cycle

The Boyd Cycle, which was first developed to describe the interactions of fighter pilots in aerial combat in the Korean War, is clearly instructive in showing the importance both of making the right decision and making it in the right time frame in the physician's fight for the patient's well-being (Figure 5).

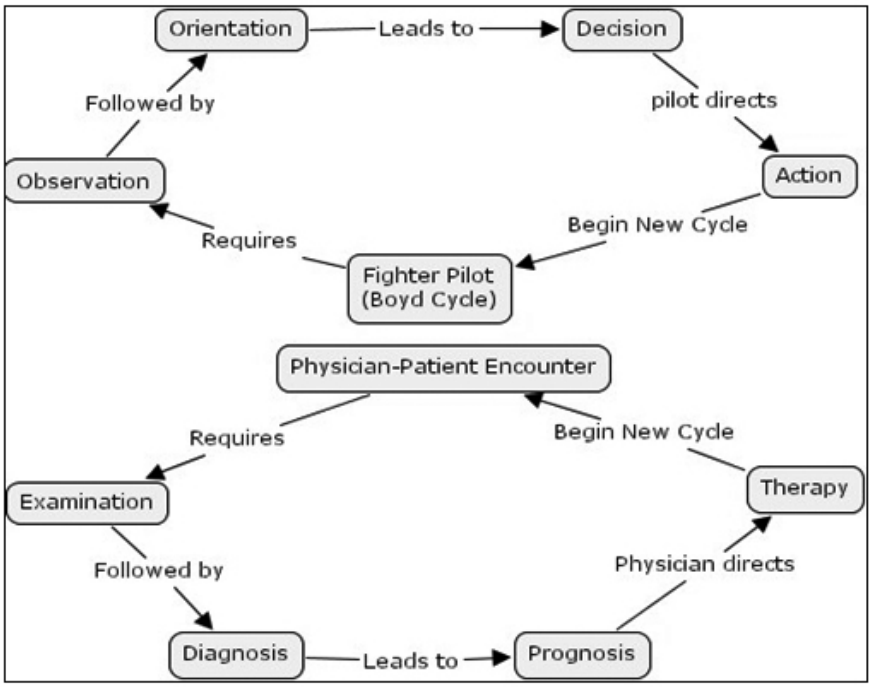


Figure 5. OODA Loop – Medical Decision Cycle

The other critical use of clinical documentation is to facilitate learning and discovery to improve the understanding and treatment of disease. The earliest uses of such documentation go back to the earliest written records of ancient civilizations where written and oral transmission of medical knowledge was used. The formal case study and the earliest epidemiologic research relied on careful observation and documentation that were supported by the evolution of the scientific method that began in the late Renaissance. Research of this type has continued to this day, with many modifications and refinements of design, interpretation, and mathematical analysis. The Double Blind Controlled Clinical Trial has been the Gold Standard of research for almost 50 years, with many successes to its credit. These studies have become increasingly complex, costly, and, in many cases, have outcomes where the difference between the successful and the unsuccessful may be statistically, but not particularly clinically, significant. There may be so many years between the beginning of these studies and their availability for evaluation, discussion, and incorporation into clinical practice that they may become obsolete by the time they are finished. The fundamental element of any clinical trial is the study protocol. A protocol standardizes not just the words of a study, such as a description of pain, but standardizes the meaning of the words, i.e., the semantics. This allows for the combination of standardized elements in order to perform comparisons and contrasts between populations. Standardization also brings the ability to extract, or factor, recurring or unique elements in the study population. The challenge of 21st century medical science is to develop the tools that are necessary to deal with the superficial, or phenotypic, human heterogeneity in the context of explosive discoveries in the underlying standardization, or genetics, of the human species.

The True Electronic Research Library (True ERL) initiative of the Washington National Eye Center has begun the development of tools to capture the detailed empiric descriptive knowledge that is necessary to completely, correctly, and continuously model one specialty area of clinical medicine, ophthalmology. We have been developing Cmaps with high complexities that capture clinical concepts that can be observed, measured, or elicited. Examples of such Cmaps are clinical descriptive models of the iris (Figure 6), and of the macula lutea of the retina (Figure 8).

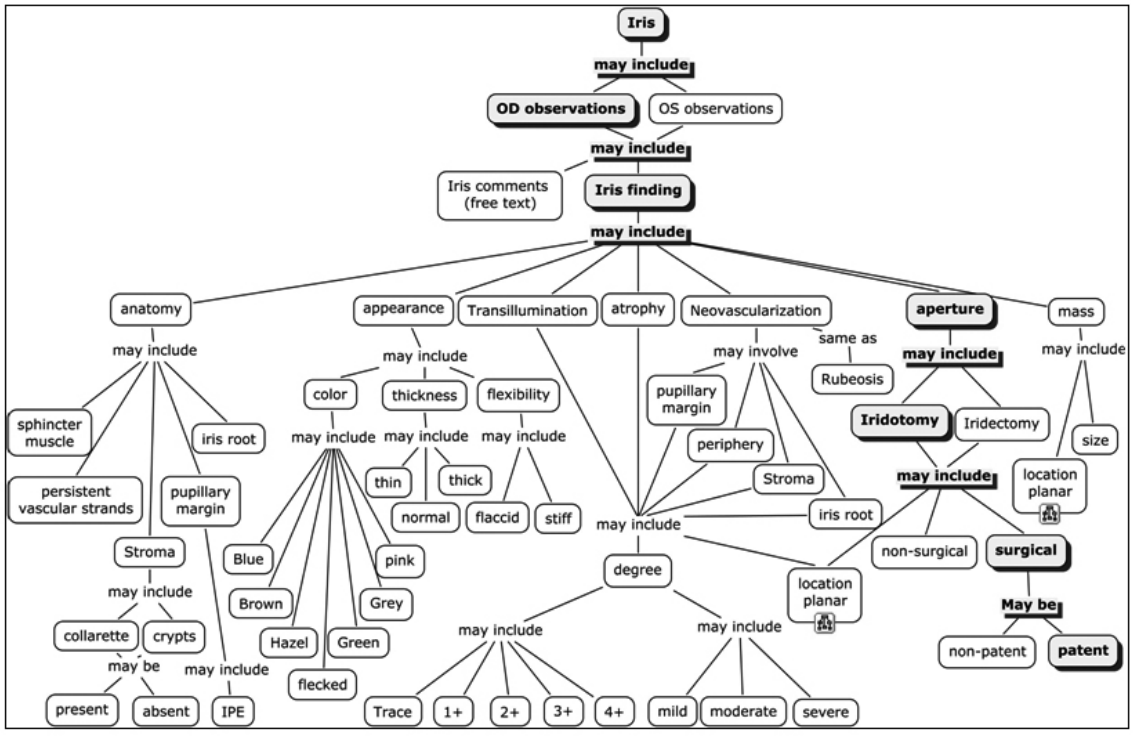


Figure 6. Iris Description Model

The highlighted propositional chain in Figure 6 may be considered as the foundation of a discrete, complete, and unique clinical statement. This clinical statement can be extracted as a linear Cmap (Figure 7) to clarify how this approach can be used to capture and store empiric data in a new and revolutionary way.



Figure 7. Iris Clinical Statement.

Figure 7 may be interpreted, in English, as:

The right (OD) iris has a finding which is an aperture which did not involve removal of iris tissue (which would be an iridectomy) by surgical means and which iridotomy is through-and-through the iris.

The Cmap of macular observations (Figure 8) with the linked sub-Cmaps (Figures 9 & 10) is a highly complex representation of what a comprehensive ophthalmologist may wish to describe on a clinical examination. It is almost certainly incomplete from the perspective of a retinal specialist. It is the power of the Cmap graphical and logical structure that easily permits additions and alterations in a knowledge model. Such knowledge models may, in turn, be used to construct a clinically useful electronic medical record (EMR).

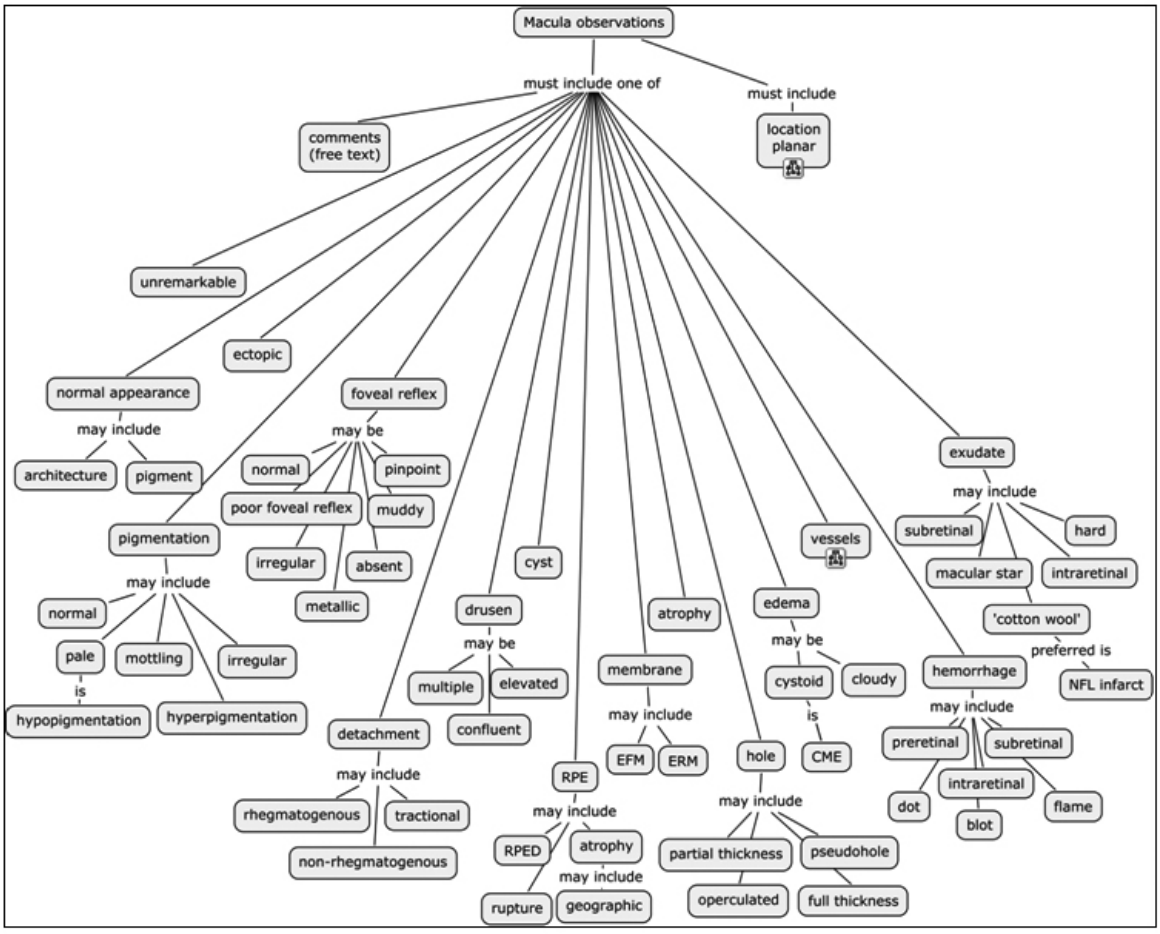


Figure 8. Macula lutea Description Model

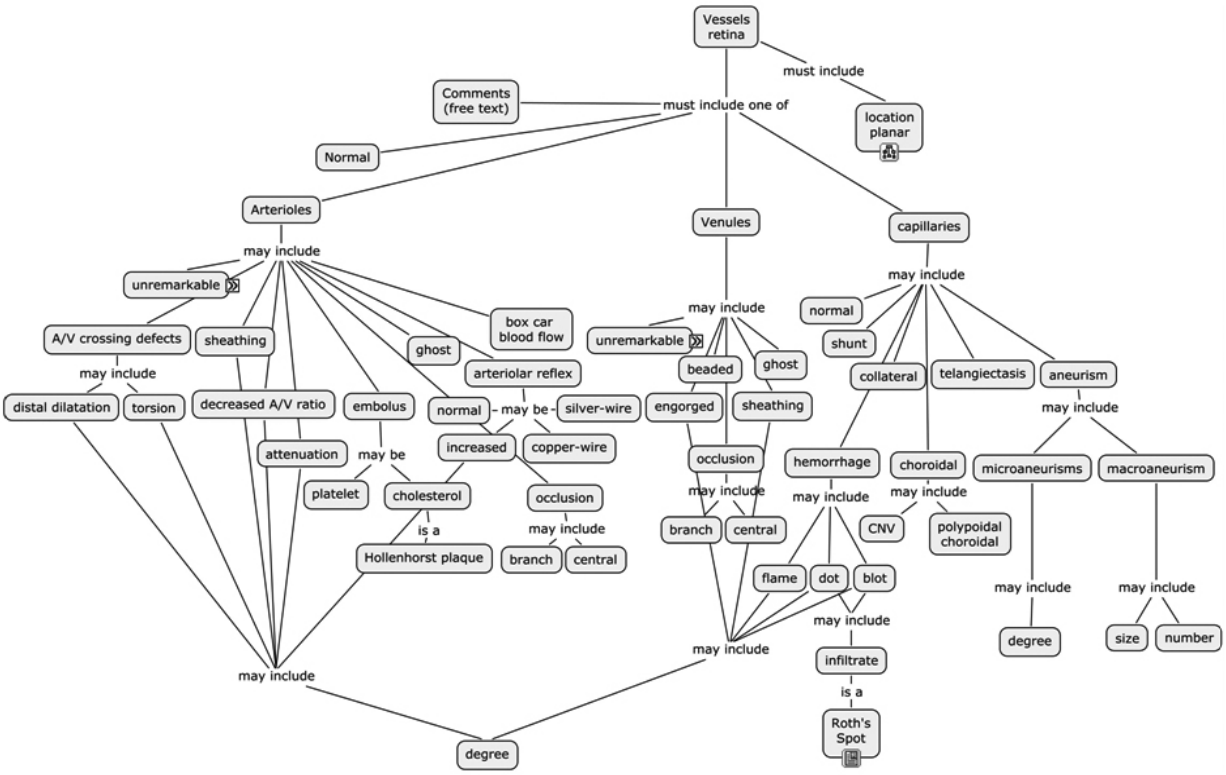


Figure 9. Vessels Retina linked Cmap from Fig. 8

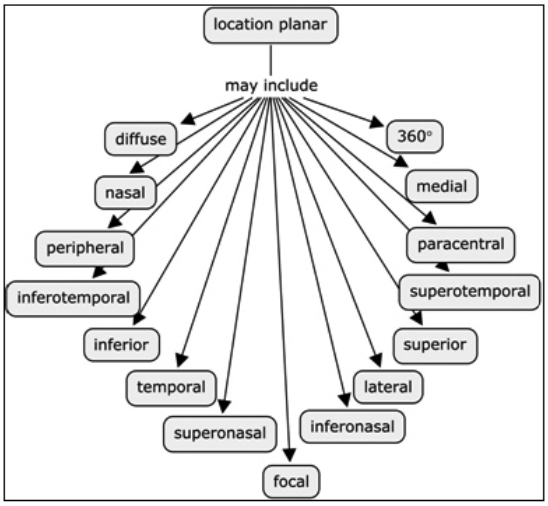


Figure 10. Location Planar linked Cmap from Figs. 6, 8, & 9

We intend to continue to elaborate these representations with the help of our specialty and sub-specialty colleagues. MedTrak Systems, an EMR and practice management systems developer and vendor, in collaboration with the True ERL, has developed software that can automatically convert Cmaps into EMR templates, checklists, etc. We believe that the tools and processes that the True ERL is developing for ophthalmology can be used to model the rest of medical knowledge. It is the purpose of this paper to introduce the use of concept mapping as a powerful tool in the continuous development and management of 21st century medical knowledge.

3 Summary

Medical knowledge structure and logic are highly complex. Simple hierarchical transactional and lexical models are not suitable to accurately reflect the practice of medicine as exemplified in clinical documentation and decision cycle analysis. Cmapping provides a tool that can significantly contribute to building a foundation for a dynamic, inclusive, collaborative, and cost-effective process of medical documentation that can meet the challenges of 21st century medicine.

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THE IMPORTANCE OF ANIMATION AS A VISUAL METHOD IN LEARNING CHEMISTRY

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Abstract. We examined differences in students' motivation and learning outcomes as resulting from two different teaching methods. For the first group visual material was presented in a traditional paper form. For the second group the material was presented via the computer animation. We examined what kind of concept maps were created by the students before and after studying process and what kind of differences were between the knowledge tests before and after the learning. The results were assessed by the changes between the results of the knowledge tests and concept maps. While we were looking at the concept maps, created after animation, we saw a visual similarity (which did not exist before the learning process). Comparing the concept maps, which were made after studying from the paper or the animation, we could see changes in the structures. By their structure, concept maps of the animation- learned students had become more similar to each other. After analyzing individually made concept maps, we created concept maps of the groups. We could notice change of centralities and structures of the maps after the studying process. This study confirmed that teachers should use visualisation tools – such as animations- purposefully during the learning process.

1 Introduction and theoretical background

Over the last decades, studies from many countries have pointed out the decreasing interest of basic and secondary school students towards science (Nakhleh, 1992; De Vos & Reiding, 1999; Mullis et al., 2004; Van Driel et al., 2007; 2008, Elliott & Paige, 2010). Many reasons have been observed as causes of this. Respectively, the proposed resolution strategies to make science more attractive to students also vary. Some researchers primarily focus on methodological innovation and diversification. Investigations have indicated the necessity to apply innovative methodology and technology – such as videos and animations – to promote better learning outcomes, motivation and application skills (e.g. Moreno & Ortegano- Layne, 2008; Cardoso et al., 2009). Others, while recognising the importance of methodological considerations, attempt to go deeper and focus primarily on the teachers' general attitudes and beliefs. Differences in teaching practice in this case are not reducible to methodological issues, but rather to the differences in teachers' aims at some more general science learning goals, that lie beyond the subject itself (Van Driel et al., 2008). Working within and elaborating the theoretical model of Roberts (1995), Van Driel and others, for example, have distinguished science teachers' attitudes towards the aims of science teaching. These aims, or 'curriculum emphases', may vary from stressing science as cumulative, reliable and valid knowledge (a traditional science curricula) to using science as a way to understand and to explain both technology and everyday occurrences (Van Driel et al., 2008). On that basis, large-scale curricular reforms in science education are proposed and discussed (ibid).

In Estonia also, the low popularity of science among students is a pressing problem (Mullis et al., 2004; Teppo & Rannikmäe, 2005). While the knowledge level of Estonian students in science, as compared with that of students from other countries, has shown relatively satisfactory, the most pressing problem is the students' motivation and attitudes towards science (Martin et al., 2004). The situation compels to seek for new ways to motivate students, thereby without turning the attention away from the importance of good learning outcomes. The research has also referred to the necessary changes in Estonian science teachers' understanding of science and teaching (Rannikmäe et al., 2008). Also it is discussed the necessary changes in Estonian teacher education in preparation of science teachers (Kask et al., 2008).

The current investigation has examined the differences in motivation and learning outcomes as resulting from two different teaching methods used in chemistry lessons for final-grade students in an Estonian gymnasium. It was stu-

died the differences provided by learning via animation one hand and via the traditional paper text on the other hand.

Our research questions are:

1) How is the knowledge of students influenced from the animation and the paper based instruction? (How do students link concepts before and after the learning process? What kind of new relationships between concepts they create after learning process?)

2) What kind of different learning outcomes (facts, knowledge, linking concepts) are acquired in different groups of students?

3) Are the familiar (learnt and used for years) and new concepts connected similarly in different groups? Are there any differences in group concept maps comparing the animation and paper group?

It is acknowledged that no method alone, apart form the context and teacher's general attitude towards science and teaching, can be seen as a proper solution. However, a competency in using new technological media as well as knowing their limitations is a promising way to enhance the students' motivation and better learning outcomes in science studies.

Animation

Several studies have demonstrated positive impact of animations on understanding abstract processes. In general educational terms, animations can be viewed as a technique of visualisation. According to Mayer and Moreno, animation refers to a simulated motion picture depicting movement of drawn (or simulated) objects (Mayer & Moreno, 2002). Together with other techniques elaborated as a result of rapidly developing information and communication technologies, use of animations has been strongly encouraged as an innovative, constructivist and students-centred alternative to the traditional learning approaches in many countries (e.g. Moreno et al., 2001; Neo & Neo, 2009). Studies from many countries have demonstrated positive effects which the use of different and innovative methodologies and visualisation technologies may have to students' understanding of central scientific concepts (Wu & Shah, 2004; Kozma & Russel, 2005; Nakhleh, 1992). The visual illustration makes it possible to prevent the formation of students' misconceptions and to guide them to the new knowledge. Animations as moving illustrated materials are used more often at schools to depict dynamic changes over time and location, and illustrate phenomena or concepts that might be difficult to visualise (Nakhleh, 1992; Mayer & Moreno, 2002; Ruiz, Cook, & Levinson, 2009). Usually these are processes, which are too slow or fast, in the nano- or microstages (Lowe, 2004; Kozma & Russell, 2005). When acquisition concepts is episodic, it could become an inhibitory factor, which is hindering the personal development of a student. (Tamm & Tuulmets, 2005; Henno et al., 2007).

Also in Estonia animations have been shown to be beneficial in science lessons (Soika, 2007). The use of activating and innovative learning technologies in Estonia is also encouraged by the new national curricula for basic school and gymnasium (Põhikooli... 2010; Gümnaasiumi... 2010). In these official documents, learning is emphasised as a process during which a student actively constructs personal knowledge in continuous interaction with his/her social environment (Põhikooli... 2010, § 5, p.1, Gümnaasiumi… 2010, § 6, p.2). Accordingly, in establishing the requirements for the social, cognitive and physical environment of learning, the usage of strategies based on new information and communication technologies is also highly emphasised (Põhikooli...2010, § 6, p.4; Gümnaasiumi… § 7, p.5). Together with the general ethos of constructivism, it may be argued that the application of animations in science lessons in Estonia is, theoretically at least, relatively well- prepared.

However, besides the acknowledged positive effects, there are also some dangers involving the use of animations in the learning process. The most important benefits of animations are: 1) they assist to understand abstract and invisible processes (Sanger, Brecheisen & Hyneki, 2001) 2) they can improve students' learning motivation- it is easier to understand abstract and difficult themes (Rieber, 1991).

The disadvantages of animations are: 1) in some situations animations may decrease the effectiveness of studying process (Ruiz et al., 2009) 2) the impact to students' mind is not determined, thus understanding the information of the animation, may differ, it also depends on the sex and the spatial visualisation understanding ability (Wu & Shah, 2004).

Concept mapping

There are several opportunities to determine the achievement of knowledge: tests, interviews etc. Concept mapping method was used in this study. By this method concepts are linked with labelled lines to proposition. Thus the concepts create a graphical structured meaningful relationship (Ruiz-Primo, Schultz & Shavelson, 1997). Usually phrases are composed of concepts that could be words, phrases or symbols. Structure of the map expresses the knowledge of student; it reflects how the concepts, ideas and rules are connected in students' mind (Reiska, Cañas, Novak & Miller, 2008; Ruiz-Primo et al., 1997; Novak, Gowin & Johansen, 1983; Chang, Sung, Chang & Lin, 2005). The method is based on the theory of Ausubel (1968), which assumes, that learners construct their knowledge, and they are influenced from the knowledge they already knew.

It has been found out, that the method is effective for testing. It helps to determine the level of the students' knowledge before the instruction (Reiska et al., 2008). Concept mapping as an assessment tool, gives better overview of the students' mentality and the structure of it, than ordinary assessment tools (Gouli, Gogoulou & Grigoriadou, 2003). Some authors point out, that the weakness of the concept mapping method is that for novice it is hard to create the structure and for instructors it is hard to evaluate the result (Chang et al., 2005).

In this study we attempted to analyze how students link concepts before and after the learning process, what kind of new relationships between concepts they create after learning process and are there any dissimilarities in the maps that are composed by students who had studied from different materials.

2 Methodology and data collection

We examined differences in students' motivation and learning outcomes as resulting from two different teaching methods. For the first group visual material was presented in traditional paper form. For the second group the material was presented via the computer animation. We examined what kind of concept maps were created by the students before and after the studying process and what kind of differences were between the knowledge tests before and after the learning.

The selection consisted of 41 students from gymnasium final grade (about 18 years old students), who had designed concept maps before. The animation and knowledge tests were represented in the Moodle learning environment, which was familiar for the students from previous lessons. The study took place two days, so the number of students varied: 29 students created concept maps before and after the studying process (see Fig. 1.), but all of them answered to the both knowledge tests.

We created similar materials for those who studied from paper based instruction and for those who followed the animation. In both cases the material contained identical information (as a text or as a voice), Figure of process and pictures of the topic. Students studied individually from the materials (see Fig. 2.). We followed the main multimedia principles while the animations had created (Mayer & Moreno, 2002; Ruiz et al., 2009). The animation explained invisible processes of micro stage. It was interactive- students had the ability to use control tabs. The animation was two- dimensional and we did not use many different colours, high speed and molecule models in the animation. The animation contained voice explanation, the most important facts and rules were accentuated textually. Excessive effects (fast moving, incoming, contrasting colours etc) were not used.

Before and after the studying process the students were asked to (see Figure 1.):

1) answer to 7 questions from the test of knowledge (open-ended and multiplied choices questions);
2) create a concept map from 15 concepts. They had 25 minutes for that (the concepts were: electrolytic dissociation, hydration, ion, water, salt, ionic bond, covalent bond, cation, anion, destroying the bond, formation the bond, crystal, molecular substance, non-molecular substance and solution).

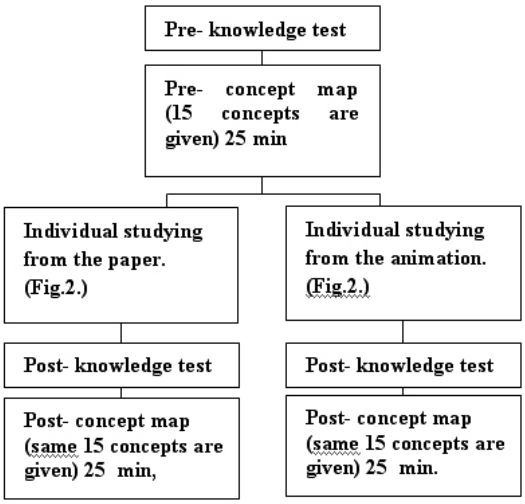


Figure 1. Design of data collection

Data was analyzed in 4 groups:

1) before studying:
- students who had used the animation,
- students who had learned from the paper;

2) after studying:
- students who had used the animation,
- students who had learned from the paper.

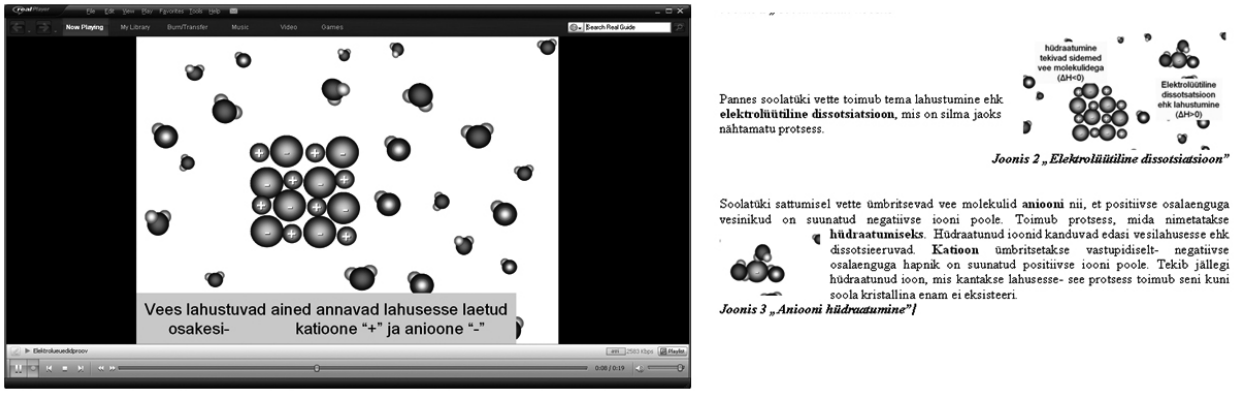


Figure 2. Screenshot of the animation and a part of the paper based instruction

The results were assessed by the changes between the results of the knowledge tests and concept maps. While we were looking at the concept maps, created after animation, we saw a visual similarity (which did not exist before the learning process). That was the reason we created a classification:

1. Propositions, consisted only concepts of the diagram (see Figure 3.) (was presented in the studying material),
2. propositions, which consisted concepts from the diagram (see Figure 3.) and outside of it,
3. propositions which contained concepts only outside of the diagram concepts (see Figure 3).

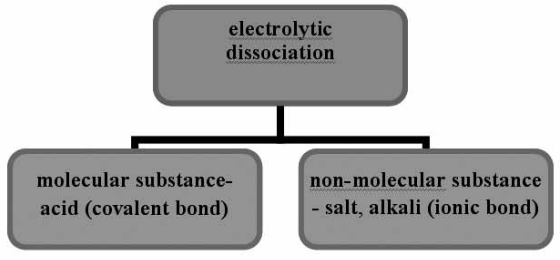


Figure 3. Diagram which was presented in the animation and on the paper

3 Results

Comparing concept maps, which were made after studying from the paper or the animation, we could see changes in the structure of maps. By their structure, the concept maps of the animation- learned students had become more similar to each other. They seemed to contain a sort of copied information, which was presented in the diagram of the animation. This diagram was also presented on the paper, but the reproduction rate in the concept maps was rare.

Comparing the concept maps before and after the learning process we can notice following (see Figure 4.):

1) The number of generated propositions had changed: students, who had studied from the paper represented more propositions with the concepts of internal and external to the presented diagram concepts. When we account the number of conjunctions of animation- learned students' pre-maps and after-study- maps, we could see changes. Animation- learned students created less propositions after learning process. The number of propositions of diagram inside concepts was extremely increased, but as a result, the total sum of the propositions was smaller than the same result of paper studied students.

2) There was a change in the centrality of the concepts. Students from the animation group had created less links between the concepts, than they had done before the learning process - the number of the propositions had decreased with several concepts. Comparing data with the group, who had studied from the paper- based instruction, we can notice that students, who had studied from the paper based instruction, linked more concepts than those who had studied from the animation. Finally we noticed that in the animation group the centrality of concepts had extremely increased in some of the concepts (are shown in the diagram), those concepts were presented in the Figure.

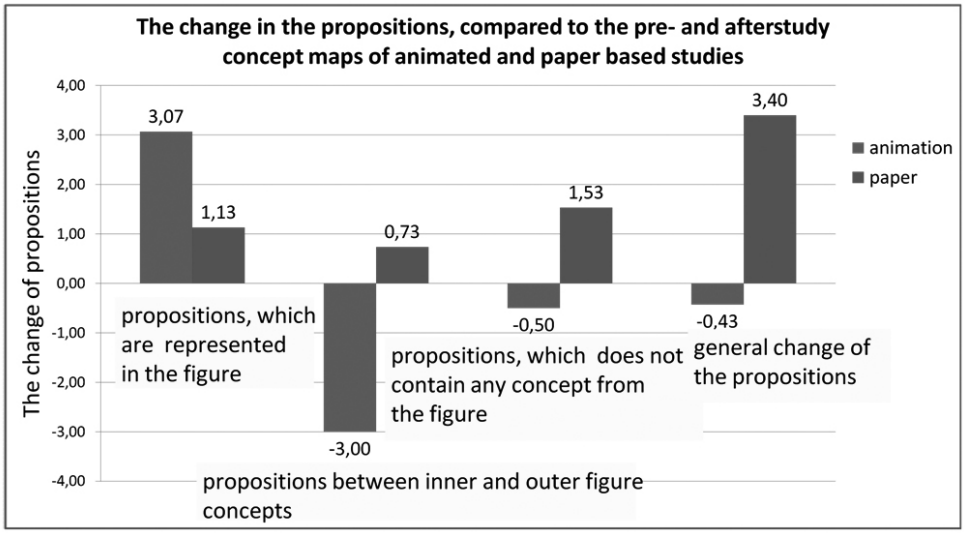


Figure 4. Changes in propositions of concept maps- comparing before and after study maps

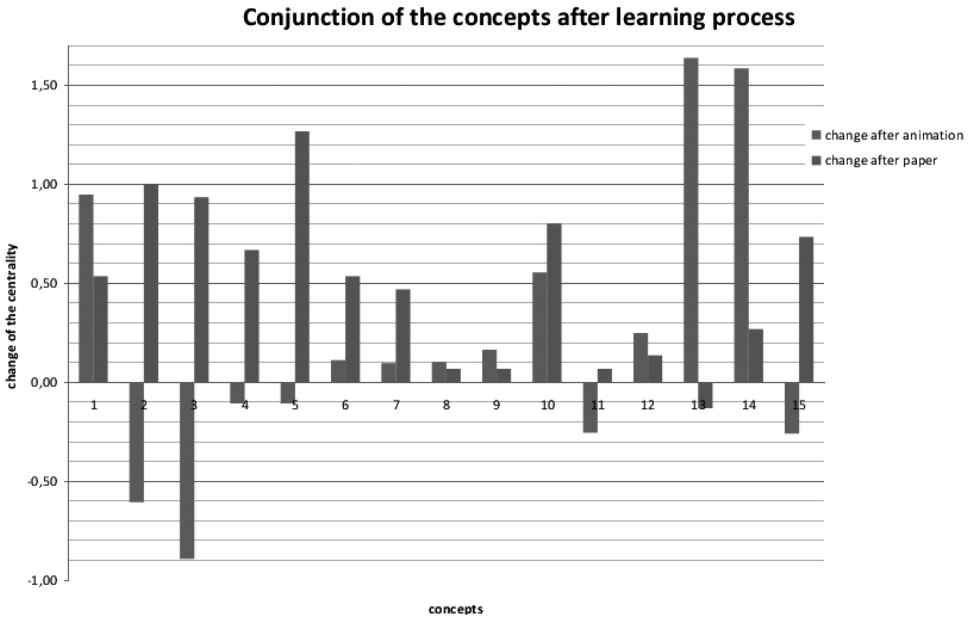


Figure 5. Conjunction of concepts before and after learning process

In the Figure 5.: numbers were given to every used concept (1=electrolytic dissociation, 2=hydration, 3=ion, 4=water, 5=salt, 6=ionic bond, 7=covalent bond, 8=cation, 9=anion, 10=destroying the bond, 11=formation bond, 12=crystal, 13=molecular substance, 14=non-molecular substance , 15=solution). We can see that the negative change is mainly represented in the group of animation between the out Figure concepts. More propositions had created with the main concepts of the Figure: as electrolytic dissociation, molecular substance and non molecular substance.

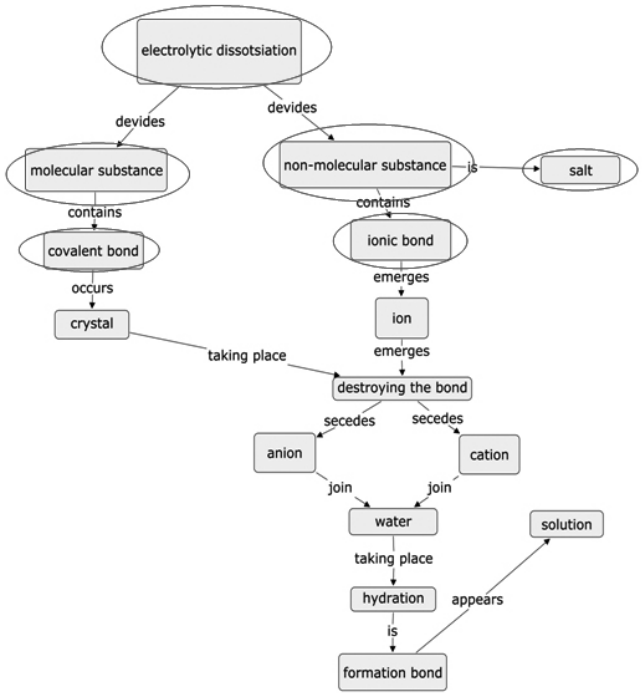


Figure 6. Concept map- created after animated study. Concepts from the diagram are circled.

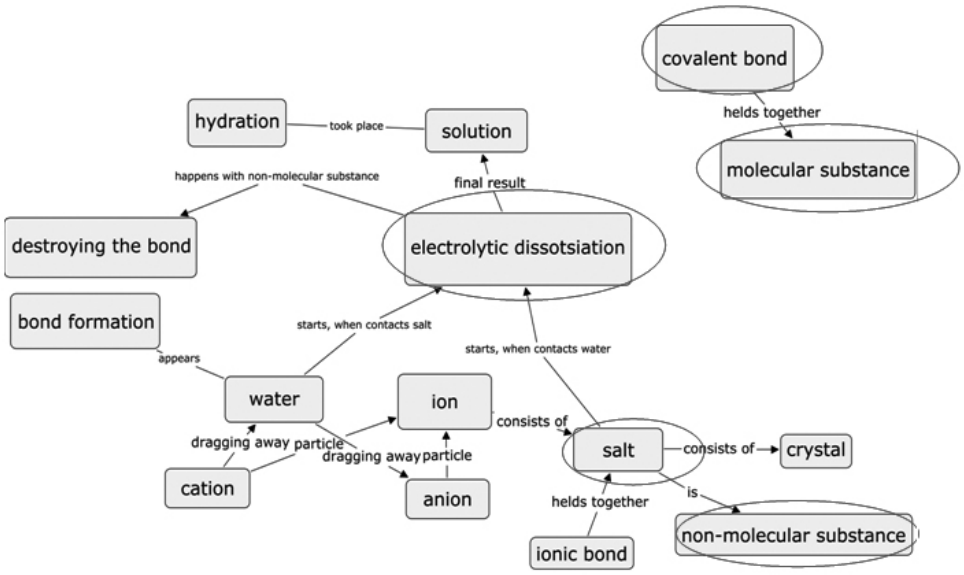


Figure 7. Concept map- created after the paper instructed study. Concepts from the diagram are circled

After analyzing students´made concept maps, we created the concept maps of the groups (from the most presented propositions). We can notice the change of centralities and structures of the maps after studying process. The links between the concepts were numbered by the classification that was created after the presented figure (see Figure.3.)

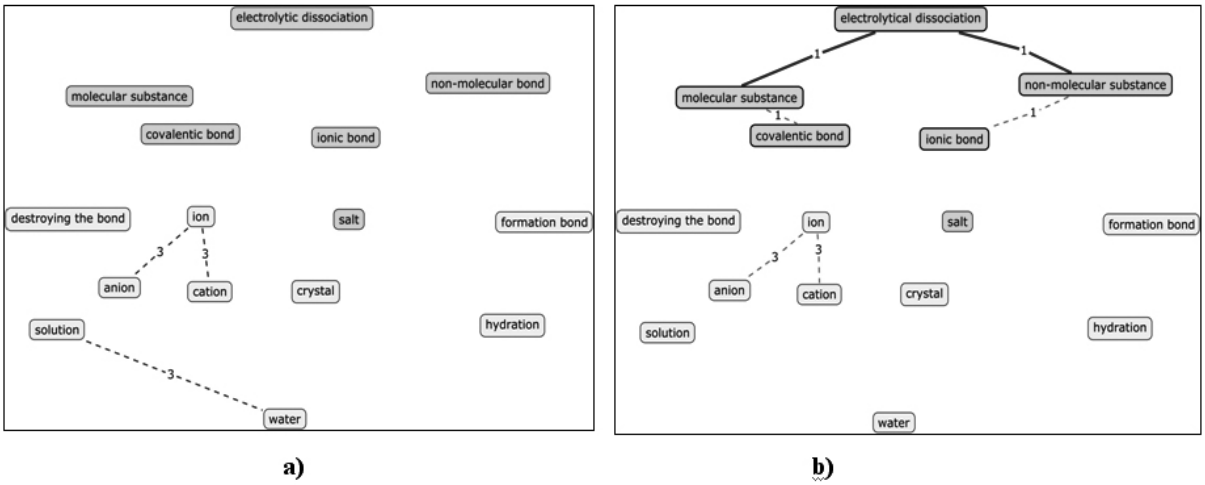


Figure 8. Comparison of the group concept map: a) before the animation b) after the animation

Propositions, concepts which are linked with a line, were represented in the 100% of students maps; dotted line proposition was created in the 84,1%- 57,1% of maps. Terms, which are darker, were represented in the Figure. Propositions: ion- cation, ion- anion and water- solution are used in chemistry lesson often. Propositions: electrolytic dissociation- molecular substance and electrolytic dissociation- nonmolecular substance were presented in the Figure.

As a conclusion we can say: a) the results of knowledge tests were similar of both groups (there were not significant differences, which would depend on the studying method); b) students, who had studied from the animation, represented the structure of the Figure (which was in the animation and paper based instruction); they create less links with concepts than before the studying process; c) students, who had studied from the paper based instruction, had created more propositions and all of them had created differently structured concept maps. In that study the structure of the concept maps (created propositions) and the number of the propositions depended on the individual studying method.

4 Discussion

This study confirmed that teachers should use visualisation tools – such as animations- purposefully during the learning process. Understanding visualised material is easier than to read information from the paper- based instruction. As human beings are lazy by character so students would like to find the easiest way to understand difficult processes - at least to show to the teacher that they had understood the theme. Understanding paper- based instruction needs concentration and conceptualising skills. That could be the reason why the main change of the data occurs in concept maps, made after the animated study- there were not many different propositions. A student, who had studied from the paper based instruction, had to analyze the information and to connect the fact with rules and other facts- she had to know the background. A student, who had studied from the animation, did not need to analyze the process deeply, she did not have to know (or create) the background of the concept. Students from the animation group got the whole information from the presentation and so they did not have to create their own understanding- the concept maps were similar and reminded the structure of the Figure, which they had seen before.

Studies have pointed out that using animation in the lesson helps to increase learning motivation. It makes difficulty understood problems easily understandable. Students explained the necessity and feasibility of the animation: *"… such teaching is more interesting and engaging, animation helps to understand the topic easily and clearly. Very often there is no use of explaining the theme only verbally, because the student is unable to imagine the process realistically and that is the reason she does not create links with other concepts and it is hard to memorize it…, … these (animations) makes the material understandable. With them it is easy to understand the motion of the particles and it is easy to explain everything, verbal explanations will justify it all…,… I am not able to concentrate enough to understand everything, it is much easier to study with the animation and teacher…"*

Some intriguing questions arose while conducting this study: What do we expect as the learning outcome from the student? Do we prefer factual knowledge of concepts to the ability to connect concepts with each other and a using them widely? Should we raise students' motivation to learn some subject, while we same time retard the ability to analyze the process? How much should a student study individually in front of the computer?

In this study we used the animation by itself. There was no communication between students and a teacher. Every student followed the animation individually. In the future we should find out if there are any variations, when a teacher uses the animation as a visualization tool in the lesson.

We got some ideas for the future studies. It would be useful to compare the animation impact on long-term memory. While students like to follow animations in the lessons, we should analyze what kind of influence they have to the learning process, when the lesson is instructed by the teacher. In the future studies we should examine more, how students are influenced, when there is a structured Figure in the presentation- how they are able to link the concepts with each other.

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J.Sánchez, A.J.Cañas, J.D.Novak, Eds.
Viña del Mar, Chile, 2010

UN EJEMPLO DE LA IMPORTANCIA DEL MAPA CONCEPTUAL COMO HERRAMIENTA INTEGRADORA ENTRE DISCIPLINAS

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Abstract. En el artículo que se presenta queremos mostrar cómo se pueden emplear los mapas conceptuales como herramienta facilitadora que ayude a entender qué contenidos de una materia son necesarias para el estudio de otra distinta. Vamos a comprobar cómo es posible, haciendo uso de los mapas conceptuales, relacionar dos disciplinas aparentemente muy diferentes como son las Matemáticas y la Economía. Para ello hemos desarrollado un ejemplo relacionado con las asignaturas de Matemáticas y la Teoría Económica, haciendo énfasis en los aspectos económicos relacionados directamente con elementos propios de las Matemáticas como pueden ser el Álgebra, el Cálculo, la Optimización, etc. Las mayores dificultades de la creación de un mapa de las características del que proponemos provienen de la necesidad de conocer en profundidad ambas disciplinas. Cuando esto no es posible se necesita un trabajo en equipo que permita a los especialistas de cada tema ir coordinando y componiendo los conceptos necesarios para elaborar el material conjunto de estudio. No debemos caer en la trampa de pensar que un mapa definido para explicar el papel de las Matemáticas como herramienta para el estudio de la Economía es algo cerrado y único. En cada momento podemos ampliarlo a medida que introducimos nuevos conceptos de la Teoría Económica que requieren de nuevas herramientas matemáticas, las cuales se van incorporando hasta alcanzar la configuración óptima del mapa conceptual.

1 Introducción

Actualmente los mapas conceptuales desempeñan un papel de importancia indiscutible como herramienta para el estudio y la adquisición de conocimientos en cualquier disciplina [Ballesteros, A.]. No en vano cada vez es mayor el número de docentes que lo emplean incorporándolos con naturalidad en el desarrollo de todo tipo de materias [Ontoria, A.]. Con este trabajo queremos poner de manifiesto un nuevo enfoque que demuestre la utilidad que tienen los mapas a la hora de conectar dos disciplinas bien diferenciadas. En el presente artículo vamos a comprobar cómo es posible, haciendo uso de los mapas conceptuales, relacionar dos disciplinas como son las Matemáticas y la Economía, destinada la primera a servir de herramienta de soporte para el estudio y compresión de la segunda. El enfoque que proponemos hace uso de los mapas de conceptos para mostrar cómo es posible justificar los contenidos matemáticos necesarios para la comprensión de la Teoría Económica.

Las Matemáticas son una de las materias que se emplean más frecuentemente a la hora de emprender estudios en distintas disciplinas o ramas de conocimiento. Los contenidos relacionados con el Cálculo o el Álgebra son los más habituales. En otras ocasiones los conceptos más necesarios son los relativos a las aplicaciones estadísticas. Así, por ejemplo, vemos como las Matemáticas son necesarias en el estudio de las ingenierías, en las licenciaturas o en los nuevos estudios de grado como pueden ser Física o Química. También hemos de incluirlas, aunque con contenidos diferentes, en los programas de estudios relacionados con la Economía o la Administración y Dirección de Empresas [Antomil, J.]. Tanto en los estudios de corte puramente científico como en estos casos se trabaja habitualmente con Álgebra, Cálculo y Estadística. En otros estudios relacionados con las ciencias de la salud como pueden ser Medicina o Psicología, la presencia de las matemáticas se centra casi en exclusiva a los temas de Estadística.

Por consiguiente vemos que hay que hacer una primera segmentación en cuanto a los temas de Matemáticas necesarios en cada caso. Por otra parte, el hecho de tener que incluir asignaturas de Cálculo para grados como Medicina o Economía, no quiere decir que estos vayan a tener los mismos contenidos en una titulación que en otra. Es por ello que

en cada disciplina se debe crear un mapa motivador de contenidos adecuado a la propia disciplina. Por consiguiente en cada caso se debe desarrollar un mapa en el cual, a partir de los conocimientos que el estudiante debe adquirir, se van introduciendo los contenidos matemáticos que va necesitando. De esta forma daremos respuesta a la pregunta que, con frecuencia, plantean los estudiantes sobre ¿qué Matemáticas tengo que saber y para qué me van a servir? Los programas de matemáticas en los estudios en Economía o Administración y Dirección de Empresas incluyen temas de Cálculo y Álgebra [Sydsaeter, k.]

Con el propósito de ilustrar esta funcionalidad de los mapas conceptuales con un caso práctico hemos elegido un ejemplo sencillo sobre métodos fundamentales de Economía Matemática relacionado con los estudios de Economía y Administración de Empresas [Chiang, A.]. Al mismo se pueden ir añadiendo nuevas restricciones y elevando el grado de dificultad. De esta forma, con el incremento de conceptos económicos, se irán incluyendo nuevos contenidos matemáticos.

2 Las matemáticas de los precios del mercado

Si consideramos los Modelos Económicos como modelos matemáticos, se emplea un conjunto de ecuaciones que describen la estructura del modelo. Estas ecuaciones se obtienen cuando se establecen las relaciones pertinentes entre las distintas variables del modelo. Si llegados a este punto aplicamos las operaciones matemáticas convenientes a las ecuaciones, podemos intentar deducir un conjunto de conclusiones como resultado de nuestras hipótesis iniciales.

Una ecuación, por definición, identifica dos expresiones que tienen exactamente el mismo significado. Cuando una ecuación refleja la manera en que una variable responde a los cambios producidos en otras se denomina ecuación de comportamiento. En otras ocasiones las ecuaciones describen el prerrequisito para conseguir un equilibrio. Son las condiciones de equilibrio.

En cualquier caso la construcción de dichos modelos conlleva la elección de determinadas variables, ya que sería imposible tener en cuenta todos los factores que realmente intervienen. Cuando se construye un modelo y se dice que está en equilibrio se pone de manifiesto la falta de tendencia al cambio del mismo, salvo que se modifiquen las variables o las interrelaciones de estas en el modelo; por ello se le llama equilibrio estático. El problema típico en esta situación es hallar el conjunto de valores de las variables endógenas que cumplirán la condición de equilibrio del modelo. Podemos ilustrar esto con un "modelo de equilibrio parcial de mercado", es decir, un modelo de determinación del precio en un mercado aislado.

Hasta aquí acabamos de introducir los primeros conceptos matemáticos que serán necesarios en los estudios de Economía: son los conceptos de variable, igualdad y ecuación. A partir de ellos podemos empezar a desarrollar el mapa de conceptos matemáticos que se muestra en la Figura 1.

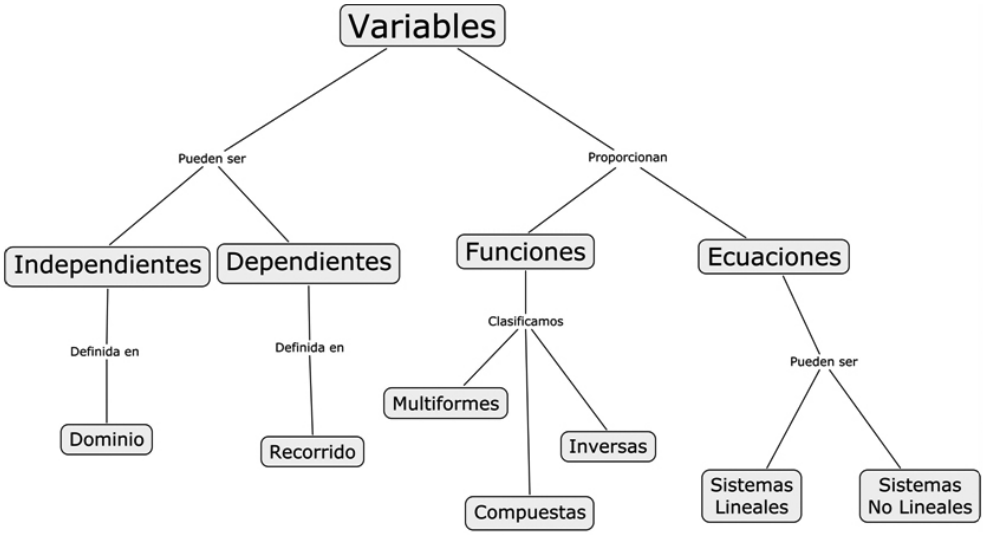


Figura 1. Primeros conceptos matemáticos.

Seguidamente vamos a establecer nuestro problema económico, es decir vamos a construir nuestro modelo. Lo primero que hemos de hacer es elegir las variables. En una primera aproximación consideramos un mercado con un único bien. Denotamos por Q_d la cantidad de bien demandada, por Q_S la cantidad ofertada y el precio del bien. Una vez elegidas las variables hemos de elaborar las hipótesis del modelo. Resulta evidente considerar como primera hipótesis que se alcanza el equilibrio en el mercado sí $Q_d - Q_S = 0$. Esta va a ser nuestra condición de equilibrio. En nuestro mapa de conceptos matemáticos, esto equivale a definir las ecuaciones que recogen las hipótesis propuestas.

A continuación nos planteamos cómo determinar los valores de Q_d y Q_S. Para ello vamos a suponer que se trata de un modelo lineal, es decir, las cantidades ofertadas y demandas son funciones lineales del precio (decreciente en el caso de la demanda y creciente en el caso de la oferta). En notación matemática podemos expresar estas condiciones como sigue:

$$Q_d = Q_s$$

$$Q_d = a - bP \qquad \text{con} \qquad a, b > 0$$

$$Q_s = -c + dP \qquad \text{con} \qquad c, d > 0$$

siendo a, b, c y d los parámetros del modelo.Nuestro mapa se va conformando como se muestra en la Figura 2. El diseño de mapa que proponemos consta de dos partes bien diferenciadas. Por una parte hemos ido desarrollando los contenidos propios de la disciplina (Economía) que aparecen en objetos rectangulares. Los contenidos matemáticos que vamos necesitando se introducen como objetos circulares. Los enlaces en negrita conectan ambos mapas:

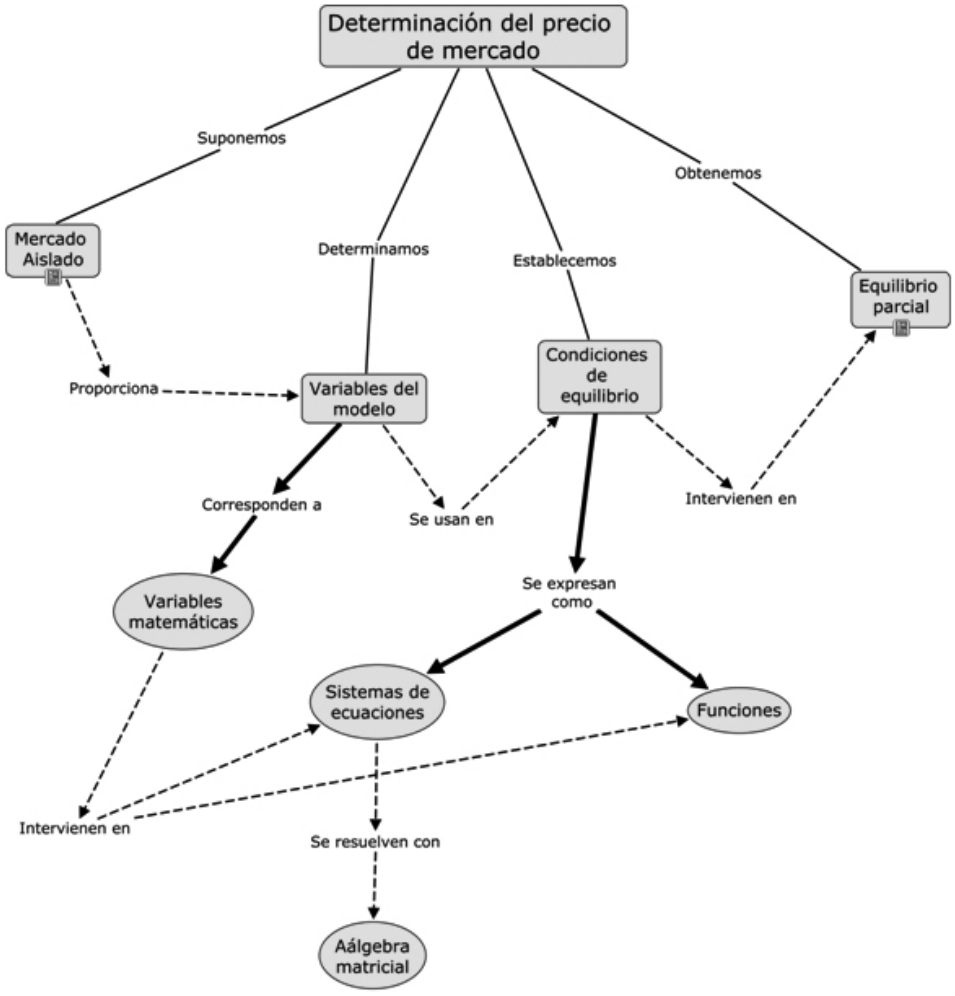


Figura 2. Matemáticas para determinar los precios de Mercado

Estamos introduciendo ahora el concepto de resolución de sistemas de ecuaciones lineales. La resolución se lleva a cabo usado distintas técnicas, y dada la sencillez del modelo es posible que lo único que necesitemos sean los métodos de sustitución, igualación o reducción o, inclusive, el método gráfico. Todos ellos se recogen en el mapa de la Ilustración 3 que se anida en nuestro mapa general.

Una vez seleccionadas las variables y definido el modelo subyacente al problema, el siguiente paso es obtener los valores de Q_d, Q_s y P que denotaremos por $\bar{Q}_d, \bar{Q}_s$ y $\bar{P}$. Como $Q_d = Q_s$ podemos reescribir $Q_d = Q_s = Q$ con lo que el modelo nos quedaría

$$\left.\begin{aligned} Q &= a - bP \\ Q &= -c + dP \end{aligned}\right\}$$

Igualando y despejando llegamos a

$$\bar{P} = \frac{a+c}{b+d} \quad \text{y} \quad \bar{Q} = \frac{ad-bc}{b+d}$$

Que es la solución de nuestro modelo. En ella hemos utilizado el método de igualación, pero se puede comprobar que es fácil resolver este tipo de ejercicios usando el método gráfico, motivo por el que se incluyen ambos en el mapa de la Figura 3.

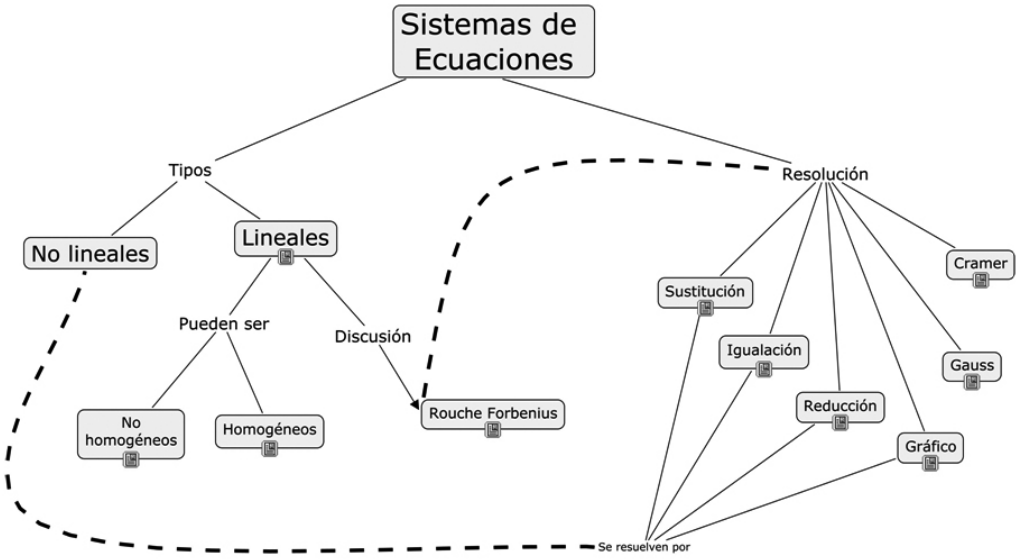


Figura 3. Mapa de conceptos sobre Sistemas de Ecuaciones

Una vez resuelta esta primera formulación de nuestro modelo podemos llevar a cabo un cambio en las hipótesis del mismo y suponer que, por ejemplo, la cantidad demandada es una función cuadrática del precio en lugar de una función lineal. Esto nos llevaría a introducir distintos métodos de resolución de sistemas de ecuaciones. Añadimos, por tanto, nuevos conceptos al mapa que reflejen la necesidad de emplear funciones.

En el ejemplo anterior, las soluciones son relativamente sencillas de hallar, pero la realidad nos lleva a incorporar más variables (bienes) a nuestro modelo. Es decir vamos, por tanto, a estudiar el equilibrio general. Cada bien llevará asociado un conjunto de variables y ecuaciones que denotaremos por:

$$Q_{di} = Q_{di}\left(P_1, P_2, \text{K}\ , P_n\right)$$
$$Q_{Si} = Q_{Si}\left(P_1, P_2, \text{K}\ , P_n\right)$$

Y las correspondientes condiciones de equilibrio

$$Q_d - Q_S = 0$$

Que podemos reescribir como

$$Q_{di} - Q_{Si} = E_i\left(P_1.P_2,...,P_n\right) = 0$$

Obtenemos de este modo un sistema de n ecuaciones con n incógnitas y hemos de estudiar la existencia de solución del mismo y, caso de que exista dicha solución, calcularla. Una parte de este problema en el que se han modificado las condiciones es común al que teníamos inicialmente. Es decir, tenemos una primera fase de identificación de variables y declaración de hipótesis que no necesita nuevos conceptos matemáticos. Por ello lo único que se modifica inicialmente en el mapa es la inclusión del Modelo General, que corresponde al mercado con varios bienes, y la obtención del equilibrio que en este caso se denomina Equilibrio General.

La resolución de este tipo de problemas comienza a ser más engorrosa. Por ello inicialmente seguiremos trabajando con la hipótesis de linealidad en nuestras ecuaciones, pero aun así debemos buscar un método apropiado que nos facilite el trabajo cuando manejamos un sistema grande de ecuaciones simultáneas. Esto lo conseguimos gracias al álgebra matricial. Ésta herramienta matemática nos permite escribir los sistemas de ecuaciones de forma compacta mediante el uso de matrices, probar la existencia de soluciones mediante el estudio de los determinantes y, en su caso, hallar dichas soluciones. Utilizaremos para ello los métodos de Gauss-Jordan, o el de Cramer.

Por todo lo anterior se hace necesario incluir un bloque temático bastante amplio destinado al álgebra matricial. No debemos perder de vista el hecho de que, al introducir estos métodos de cálculo basados en el álgebra lineal, estamos suponiendo que existe linealidad en las ecuaciones del modelo. En ocasiones esta linealidad se obtiene si hacemos estudios locales, o realizamos operaciones que nos permitan transformar nuestras ecuaciones en lineales (tomando logaritmos, etc.). Gracias al álgebra matricial podemos hallar los valores de equilibrio de las variables que intervienen en el modelo (equilibrio estático). Ahora bien, no hemos dicho nada sobre la forma en la que llegamos a ese punto de equilibrio y sobre lo que ocurre por el camino.

Una vez obtenido un estado de equilibrio, el siguiente paso es la comparación entre diferentes estados de equilibrio que están asociados con diferentes conjuntos de valores de parámetros y de variables exógenas. Al realizar un análisis cuantitativo estamos llevando a cabo, de forma implícita, el análisis cualitativo, ya que el signo de la variación de la magnitud nos dará la dirección de cambio de la misma. Nos centramos por ello en el estudio de la tasa de cambio del valor de equilibrio de una variable endógena con respecto al cambio en un parámetro particular o variable exógena. Por este motivo el concepto matemático de derivada introducida como tasa de variación juega un papel primordial en el análisis estático comparativo del modelo. De esta forma hemos entrado en el campo del análisis matemático. Ahora nuestras ecuaciones las consideramos más bien como funciones y estamos interesados en estudiar su variación (derivadas). Debemos por tanto dar una serie de conceptos matemáticos que nos permitan abordar este problema con rigor [Sydsaeter, k.], y por ello incluimos en el programa algunas nociones relativas al estudio de funciones como son la determinación de sus dominios de definición, el estudio de la continuidad -para lo cual necesitamos el cálculo de límites-, y del crecimiento y decrecimiento de la función, es decir, las derivadas.

De la comparación de los distintos estados de equilibrio surge la necesidad de elegir el más conveniente. En Economía el criterio más común de elección de alternativas tiene como objetivo maximizar algún bien o cantidad (beneficio de una empresa, utilidad del consumidor, etc.) o, por el contrario, minimizar algún bien o cantidad (por ejemplo el coste de producción o el coste de un producto). Podemos catalogar estos dos tipos de problemas como problemas de optimización. Para la correcta formulación de un problema de optimización debemos identificar, en primer lugar, una función objetivo, cuya variable dependiente represente el valor a optimizar. El objetivo será obtener el conjunto de valores de las variables independientes (o variables de elección) que nos proporcionen el óptimo deseado de la función objetivo.

Una primera aproximación, considerando funciones objetivo con una única variable, nos lleva al desarrollo de un procedimiento basado en el estudio de la derivada primera para la determinación de los extremos. El estudio del signo de la misma nos permitirá decidir si se trata de un máximo o un mínimo. Para ello podemos hacer uso también de la derivada segunda. De esta forma vemos como, a partir de la variación en las condiciones de equilibrio establecidas en nuestro modelo de mercado, hemos introducido los conceptos de derivación y optimización. Sin embargo hemos visto anteriormente que es más realista considerar modelos más generales que llevan asociados un conjunto de variables y ecuaciones. En este tipo de problemas hemos de estudiar cómo afecta la variación de cada variable al resultado final, es decir hemos de estudiar las derivadas parciales de nuestra función.

En este caso también nos apoyaremos en el cálculo diferencial para la optimización de las funciones, si bien al trabajar con varias variables nos vemos obligados a introducir nuevos conceptos. Si nos centramos en el estudio de funciones de dos variables es fácil comprobar que, para determinar el crecimiento de nuestra función objetivo, lo que debemos estudiar es el signo de la forma cuadrática que se asocia a la diferencial de la función. Vemos pues justificado el estudio de los temas relacionados con la diagonalización de matrices, ya que nos basaremos en ello para decidir si la correspondiente forma cuadrática es definida positiva o negativa.

Si damos un paso más en el desarrollo de nuestro modelo económico vemos que, normalmente, cuando una empresa necesita resolver un problema de optimización, este suele venir acompañado de una serie de condiciones que denominamos restricciones. Por ejemplo, nos puede interesar maximizar el beneficio de una empresa teniendo en cuenta que por motivos de almacenamiento o de horario deben cumplirse determinadas condiciones. Los óptimos así obtenidos se denominan óptimos restringidos. Las restricciones se pueden introducir en forma de igualdades o de desigualdades.

La optimización restringida con condiciones de igualdad se puede llevar a cabo definiendo una nueva función objetivo que obtenemos al sumar a la función objetivo las funciones que asociadas a las restricciones premultiplicadas por escalares. A esta nueva función objetivo la optimizamos como indicamos anteriormente apoyándonos en las formas cuadráticas. La nueva función construida se denomina Lagrangiana, y los escalares empleados con las restricciones se denominan Multiplicadores de Lagrange.

Por otra parte, si las condiciones impuestas a nuestro problema de optimización vienen dadas por desigualdades se debe aplicar un método de trabajo distinto. Es fácil comprobar que en el caso de dos variables, el problema se puede resolver mediante la representación gráfica de la región factible y de la función objetivo (dando distintos valores). Cuando el problema involucra más de dos variables, la representación gráfica no es posible. En esos casos se utiliza la programación matemática. Estos conceptos quedan reflejados y relacionados en el mapa de la Figura 4.

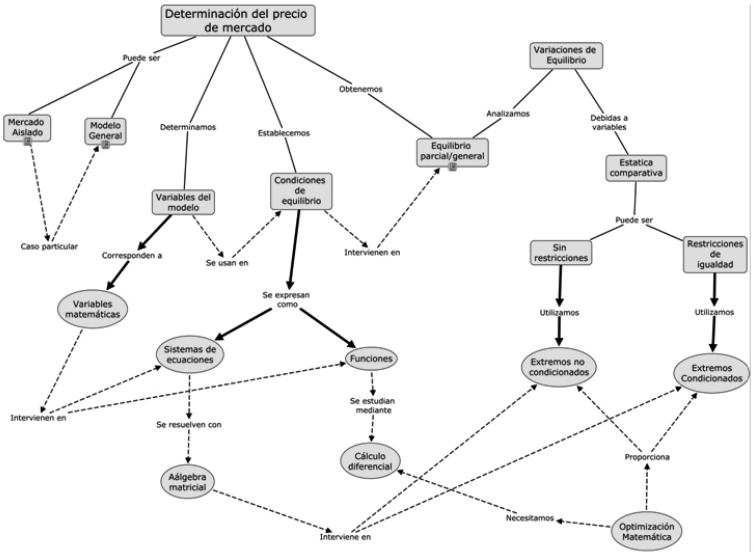


Figura 4. Estática Comparativa y Variaciones del Equilibrio

Por el momento los problemas que hemos planteado los hemos estudiado desde un punto de vista estático, es decir, sin tener en cuenta la evolución temporal de los mismos. La evolución temporal la podemos introducir de dos formas distintas, considerando el tiempo como una variable continua, es decir en cada instante ocurre algo distinto a la variable, o como una variable discreta, en este caso la variable experimenta algún cambio sólo una vez en cada periodo de tiempo considerado. Cuando se considera el tiempo como una variable continua, la derivada expresa la variación que se produce en nuestra función. Tenemos de este modo las ecuaciones diferenciales como representación de la evolución temporal de nuestros problemas. Los problemas más sencillos en este tema se resuelven simplemente aplicando las distintas técnicas de integración. Si vamos completando nuestro problema con derivadas sucesivas, esto nos lleva a la utilización de las ecuaciones diferenciales como herramienta para resolver nuestros problemas. Por otra parte, si consideramos el tiempo como una variable discreta, los métodos de resolución serán distintos. En este caso estamos ante problemas de ecuaciones recurrentes o ecuaciones en diferencias finitas.

Como vemos, en cada momento podemos ir trabajando sobre el problema económico y, a partir del mismo, introducir las herramientas matemáticas según nos vayan siendo necesarias. Sin embargo esto no resulta operativo, pues en ocasiones deberíamos parar el desarrollo de los contenidos económicos para avanzar en contenidos matemáticos. Por ello se estudian como asignaturas independientes, si bien los mapas pueden ser una valiosa ayuda a la hora de motivar la introducción de los distintos contenidos.

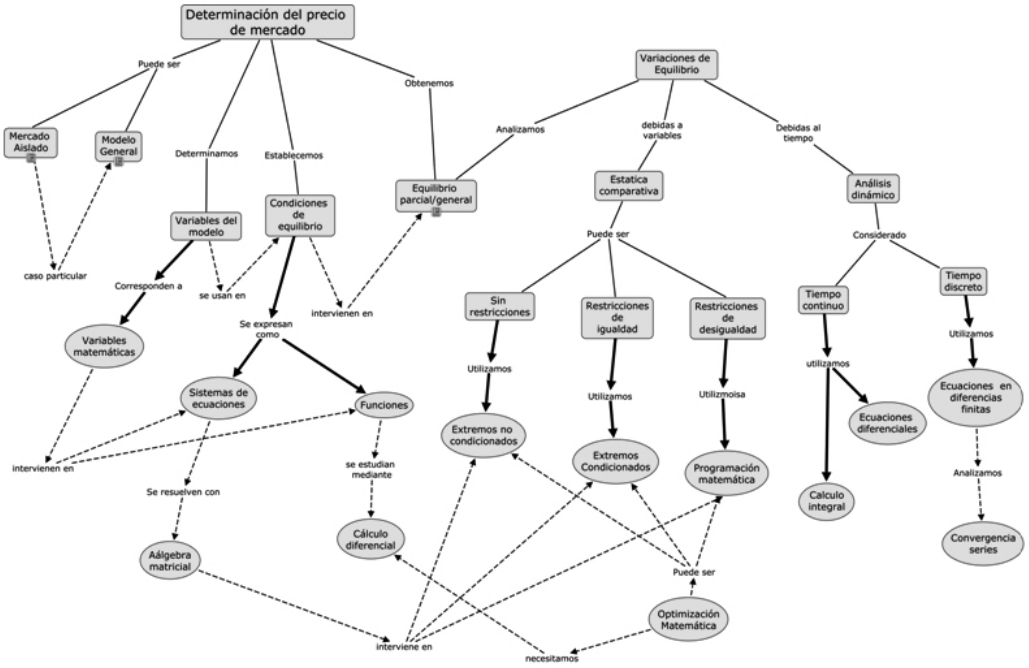


Figura 5. Matemáticas para la determinación de los Precios de Mercado

El siguiente paso sería el desarrollo de mapas más detallados y adecuados a cada disciplina en los que se detallen los contenidos que se deben introducir para resolver un problema concreto y en los que se podría llegar a un mayor desarrollo de los contenidos. El mapa al que se llega en este artículo, Figura 5, supone una aproximación con referencias a contenidos muy genéricos, si bien es posible llegar a un nivel de especificación mayor. Se pueden ver mapas con propuestas de los contenidos que se incluyen en los estudios de Economía o Administración y Dirección de Empresas en las universidades de la Comunidad de Madrid en [García, M.C.]

3 Conclusiones

En el artículo se muestra la utilidad de los mapas conceptuales para la integración de materias de contenidos diferenciados, la cual va más allá de ser una herramienta de adquisición de conocimientos. Hemos visto con un ejemplo el

importante papel que desempeñan los mapas a la hora de establecer relaciones entre distintas disciplinas, como en el caso de las Matemáticas y la Economía. La primera está destinada a servir de herramienta de soporte para el estudio y compresión de la segunda. El enfoque que proponemos hace uso de los mapas de conceptos para mostrar cómo es posible justificar los contenidos matemáticos necesarios para la comprensión de la Teoría Económica.

En este mismo sentido creemos que sería conveniente que en todas aquellas materias de estudio en las que se usan los conocimientos adquiridos en otras disciplinas, se definieran mapas similares al presentado en el artículo. De este modo sería posible diseñar planes de estudio y de trabajo perfectamente coordinados en los que el estudiante supiera en cada momento cuál es la utilidad aplicada de los conceptos que está estudiando.

La elaboración de mapas como el propuesto la estamos efectuando como parte de la labor docente que llevamos a cabo en la UNED para el desarrollo de los nuevos grados en el marco del Espacio Europeo de Educación superior (EEES) [García, M.C.]. En las siguientes etapas hemos de desarrollar mapas que detallen, para cada unidad didáctica del temario de Matemáticas en las titulaciones de Economía, ADE y similares, los conceptos matemáticos que se deben introducir para desarrollar los contenidos necesarios. En este sentido es posible, e inclusive recomendable desde un punto de vista metodológico integrador, definir mapas similares entre distintas asignaturas de un mismo título, de forma que en cada momento podamos visualizar en qué punto del programa vamos a necesitar recordar o ampliar contenidos que no están realmente incluidos en el programa de la asignatura objeto de estudio. De este modo podemos llegar a establecer mapas que reflejen el perfil que se conseguirá al finalizar el título que se está estudiando, lo cual puede permitir a los estudiantes orientar sus esfuerzos para obtener la formación más conveniente para la especialización que desea conseguir. Para llevar a cabo este trabajo es necesaria la colaboración entre los docentes encargados de las distintas materias, los cuales deberán realizar mapas en los que se establezcan que contenidos de otras materias son necesarios en el desarrollo de su propia materia, así como el momento más adecuado para que estos se vayan incluyendo.

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UNA PROPUESTA DE UTILIZACIÓN DE MAPAS CONCEPTUALES EN LA EVALUACIÓN: EVALUAR APRENDIZAJES A PARTIR DE MAPAS COLABORATIVOS CONSTRUIDOS, COMPARTIDOS, ORGANIZADOS Y CRITICADOS POR LOS ESTUDIANTES.

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Resumen. La experiencia que presentamos tiene como eje principal la aplicación de los mapas conceptuales en el proceso de enseñanza-aprendizaje, representando y compartiendo el conocimiento desde una perspectiva constructivista. Se pone especial énfasis en la fase de evaluación y específicamente en la utilización de mapas conceptuales como procedimiento de evaluación. Se trata de la utilización de mapas construidos individual y colectivamente en las entrevistas de evaluación de una materia, en la idea de que las metodologías centradas en el alumno requieren procedimientos de evaluación que apunten al pensamiento de alto nivel.

1 Introducción

Los mapas conceptuales como recurso didáctico en la educación superior presentan diversas posibilidades (Cañas y otros, 2000): utilización por el profesor como medio para presentar la información; creación de mapas por parte de los estudiantes organizador en el diseño de materiales para el aprendizaje, etc. De todas ellas, aquí interesa abordar los mapas conceptuales como integradores de la estrategia de enseñanza–aprendizaje: como herramienta en manos de los alumnos para organizar la información sobre un tema, tanto individualmente como de forma colaborativa, y, específicamente, como instrumento de evaluación. Nos ocupamos, no tanto de la evaluación de mapas conceptuales, como de su utilización como instrumentos en el proceso de evaluación.

Los mapas conceptuales pueden jugar un importante papel en el proceso de enseñanza-aprendizaje, representando y compartiendo el conocimiento desde una perspectiva constructivista (Novak y Gowin, 1988; González y Novak, 1996; Novak 1998). En Salinas, De Benito y Garcia, (2008) experimentamos con algunas de las potencialidades que presentan tanto para la representación del conocimiento de los estudiantes, como para compartir, contrastar y organizar un mapa generado de forma colaborativa, al resultar los mapas conceptuales un mecanismo adecuado para la creación de módulos de contenidos independientes (asociados en nuestro caso al mapa de cada uno de los conceptos). Cada mapa, por definición, expresa el conocimiento sobre un contexto específico. Un conjunto de mapas relacionados puede reunir el contenido de un tema o una materia. Estos mapas, por supuesto, tendrán enlaces a mapas de otros temas. Sin embargo, esta relación no se debe a la secuencia del curso, sino al contenido. Cada módulo del tema se convierte en una unidad independiente y al mismo tiempo integrada en el tema general (Educación flexible).

Se trata entonces de utilizar las herramientas informáticas que explotamos en nuestro entorno virtual de enseñanza-aprendizaje (EVEA), no tanto para intentar la instrucción de los estudiantes, sino, más bien y tal como señala Jonassen (2000), para servir de herramientas de construcción de conocimiento, para que los estudiantes aprendan con ellas, no de ellas.

Esto encaja con otro de los ejes clave del curso, dado que se orienta a las posibilidades de las TIC como instrumentos cognitivos que sirvan para ampliar, potenciar y reorganizar las capacidades de los estudiantes. Al decir de Jonassen (2000) podemos hablar de un instrumento cognitivo o mental cuando desarrolla las habilidades del pensamiento crítico, entendiendo como tal un conjunto de habilidades que abarcan el pensamiento crítico propiamente dicho (análisis, evaluación y conexión), el pensamiento creativo (elaborar, sintetizar e imaginar) y el pensamiento complejo (diseñar, resolver problemas y tomar decisiones).

2 Mapas conceptuales como procedimientos de evaluación formativa

La evaluación es uno de los elementos fundamentales del proceso de enseñanza-aprendizaje, por lo que su diseño guarda estrecha relación con la metodología de enseñanza que se utiliza. De Camillioni et alt. (1998) señalan que el proceso de evaluar atraviesa los procesos de enseñanza y de aprendizaje de manera tal, que si se analizara y modificara en profundidad la idea de evaluar se modificarían sustancialmente los procesos de intervención de los docentes y la implantación de las estrategias aplicadas.

Por ello, entendemos que el proceso de evaluación debe ser coherente con los objetivos y estrategias didácticas desplegadas. Nuestra propuesta es que los mapas conceptuales, incluso –o mayormente- incompletos, deficientes o débilmente construidos, pueden resultar un instrumento eficaz para evaluar los avances de los estudiantes en este terreno, siempre que los estudiantes hayan contribuido a su elaboración y sean conscientes de que trabajan con un mapa del que conocen las características concretas.

La evaluación, en este sentido, constituye un elemento fundamental en el proceso de enseñanza-aprendizaje y su diseño guarda estrecha relación con la metodología de enseñanza que se está utilizando. En función de cómo la evaluación sea considerada al diseñar el proceso, puede ser percibida como un juicio o como una ocasión para aprender.

Desde estos planteamientos centrados en el alumno, la evaluación debe ser vista no solo como una acción orientada a valorar el grado de cumplimiento de los propósitos de aprendizaje –un proceso para calcular y asignar calificaciones, para certificar– sino, también, como una acción de intervención dirigida a la reconstrucción de los conocimientos a aprender (Salinas, Pérez y De Benito, 2008).

Los mapas conceptuales, el la línea de lo propuesto por Novak y Gowin (1988), al ser diagramas que expresan las relaciones entre conceptos generales y específicos de una materia, reflejando la organización jerárquica entre ellos, constituyen una técnica que puede ser utilizada tanto en la enseñanza como en la evaluación, favoreciendo el desarrollo organizado y funcional de los conceptos claves de una materia o disciplina. Permite, así, analizar las representaciones que el estudiante va elaborando de los conceptos de una asignatura y valorar su habilidad para integrarlos en un esquema mental comprensivo.

Los mapas conceptuales, al constituir una poderosa herramienta de representación del conocimiento, complementan y apoyan muy bien las entrevistas de evaluación, al servir como forma de evaluar los cambios en el marco conceptual del estudiante. Junto a ello, se puede señalar la fiabilidad de los mapas conceptuales como instrumento de evaluación para revelar la estructura del conocimiento de los estudiantes (Novak, 1998).

3 La experiencia

En este contexto, lo que presentamos es una nueva experiencia llevado a cabo en la asignatura "Diseño y desarrollo de programas de educación flexible y a distancia" que forma parte del plan curricular de la carrera de Pedagogía en la Universidad de las Islas Baleares. Se trata de una asignatura que se imparte en modalidad semipresencial, con una importante proporción de trabajo online mediante materiales y herramientas telemáticas.

Como se ha señalado, se vienen utilizando los mapas de construcción colaborativa para construir, compartir, criticar modelos de conocimiento elaborados mediante mapas conceptuales por parte de los estudiantes. Para ello, utilizamos los mapas conceptuales como estrategias de organización cognitiva (Novak y Gowin, 1988).

Los estudiantes construyen cada uno de los mapas conceptuales para mostrar gráficamente el conocimiento sobre el concepto que le ha correspondido, colaboran on-line entre sí en la construcción de sus mapas, negocian las relaciones entre los mismos, los complementan con imágenes, vídeo, texto, etc., enlazándolos a los mapas de los otros estudiantes, publicando su modelo en Internet, permitiendo la navegación a otros estudiantes y contribuyendo a estructurar el conocimiento sobre la materia, mediante discusión y reflexión colectiva en clase (Salinas, de Benito y García, 2008).

La tarea que aquí presentamos se orienta a las posibilidades del mapa conceptual como instrumento de evaluación de los aprendizajes. Como se ha dicho, se trata de construir el mapa conceptual de manera colaborativa y asociarle material relevante. Al mapa final se llega por consenso a través de la cooperación entre los miembros del grupo y

basándose en estrategias de trabajo colaborativo, la tarea integra una variedad de actividades por parte de los estudiantes, relacionadas con la búsqueda, selección, organización e intercambio de información y con la organización de conceptos y sus relaciones. Pero las mismas fortalezas de la estrategia constituyen también sus debilidades y, así, el consenso puede llevar a una estructuración débil, defectuosa e imperfecta de los conceptos clave y sus relaciones. El grupo debe asumir estas debilidades y afrontarlas como parte también del mismo proceso de aprendizaje.

Es importante, por ello, que los estudiantes examinen, comenten y cuestionen estos mapas, modificándolos o añadiendo elementos, creando versiones alternativas, discutiéndolos en clase. También es importante que sean trabajados colectivamente con el profesor en clase de modo que se promueva la reflexión, la crítica y la reorganización de los modelos de conocimiento propuestos.

Los mapas de construcción colaborativa son utilizados, además, en las entrevistas de evaluación de la materia, siendo conscientes los alumnos de que dichos mapas son manifiestamente mejorables, es decir, están incompletos, inacabados, imperfectos.

Por lo tanto los alumnos saben de antemano que el mapa conceptual colaborativo en el que han participado será utilizado en dicha entrevista y que tendrá que mejorarlo y/o rectificarlo personalmente, interiorizándolo y apropiándose de la estructura para construir una propia. Esto es así porque la evaluación define de alguna manera para el alumno lo que hay que aprender, así como el valor de ese aprendizaje (Salinas, Perez y de Benito, 2008). Constituye un valioso criterio de referencia para el alumno, en cuanto al éxito o fracaso de la propia experiencia de aprendizaje y en cuanto a la calidad de dicha experiencia.

3.1 El procedimiento de trabajo

La experiencia se llevó a cabo durante 8 de las 16 semanas de duración del curso, y en ella participaron 45 de los 61 alumnos.

El proceso siguió las siguientes fases:

- Fase previa: Se realiza un taller introductorio sobre la creación de mapas conceptuales y el manejo del programa CMaptools.
- Fase primera (trabajo individual): Se asignó a cada uno de los estudiantes alguno de los 32 conceptos ya seleccionados. Dicho concepto debe documentarse, buscar información, localizar material relevante relacionado con el concepto adjudicado (artículos, páginas web, etc.) con la finalidad de elaborar su propio mapa conceptual.
- Fase segunda (Trabajo colaborativo): Consiste en una puesta en común de todos los conceptos estudiados por cada alumno a fin de establecer las conexiones entre los conceptos. Por motivos operativos se distribuye a los estudiantes en 3 grupos. Se desarrolla mediante un proceso de "negociación" entre todos los miembros del grupo, utilizando los medios de comunicación que para tal efecto se habían proporcionado a los alumnos (los propios de la plataforma de formación y los del software para el trabajo colaborativo). Una vez finalizado el proceso de negociación se construye el mapa colaborativo y se conectan los distintos mapas de cada uno de los conceptos al mapa general.
- Tercera fase (trabajo colectivo): Discusión de los mapas colaborativos en clase de forma que se van configurando, perfilando nuevos ajustes y modificaciones e introduciendo sucesivas mejoras.
- Cuarta fase (trabajo individual): Cada uno de los estudiantes, partiendo del mapa colaborativo resultante, adapta, reconstruye, o apunta el mismo de forma que domine conceptos y relaciones entre ellos.
- Quinta fase (entrevista de evaluación): Se realiza la entrevista de evaluación partiendo del mapa colaborativo construido por el grupo del estudiante.

3.2 La entrevista de evaluación

En este curso la entrevista es utilizada como procedimiento central de evaluación, en lo relativo al dominio conceptual y los aspectos teóricos del mismo. Se seleccionó este procedimiento por ser adecuado para comprobar el alcance logrado de los objetivos, para mostrar competencias respecto al pensamiento de alto nivel y a la resolución de problemas.

Se trata de una entrevista no estructurada, donde el propósito de la misma se mantiene constante, mientras que las cuestiones se van formulando siguiendo el giro de la conversación.

En relación al tema que nos ocupa, se esperaba de los estudiantes:

- Señalar las debilidades e incorrecciones que observa en el mapa colaborativo de su grupo.
- Explicar alguno de los conceptos clave al azar y las conexiones con otros afines, complementarios o subordinados.
- Indicar las mejoras que introduciría en el mapa (respecto a algún concepto concreto o cadena de ellos). Justificarlas.
- Proponer la reorganización de las conexiones de un determinado concepto a partir del propio conocimiento del mismo y de los afines.
- Describir el mapa conceptual del concepto que el estudiante realizó. Discutirlo y criticarlo.
- Explicar y discutir la integración del mapa personal en el colaborativo, señalando las debilidades y fortalezas.

4 Los resultados

Como primer resultado del proceso podemos considerar los mapas colaborativos tal como quedan una vez discutidos en clase, y que funcionan como base para preparar las entrevistas de evaluación. Como se dijo disponemos de tres mapas colaborativos diferentes.

Hay que señalar que el mismo proceso de construcción del mapa de forma colaborativa resulta un valioso logro del curso dado que se están trabajando competencias del curso relacionadas con el manejo de las TIC en procesos de consrtrucción de conocimiento en procesos de enseñanza-aprendizaje (véase Salinas, de Benito y García, 2008) En la Figura 1 se muestra un ejemplo de uno de estos mapas colaborativos.

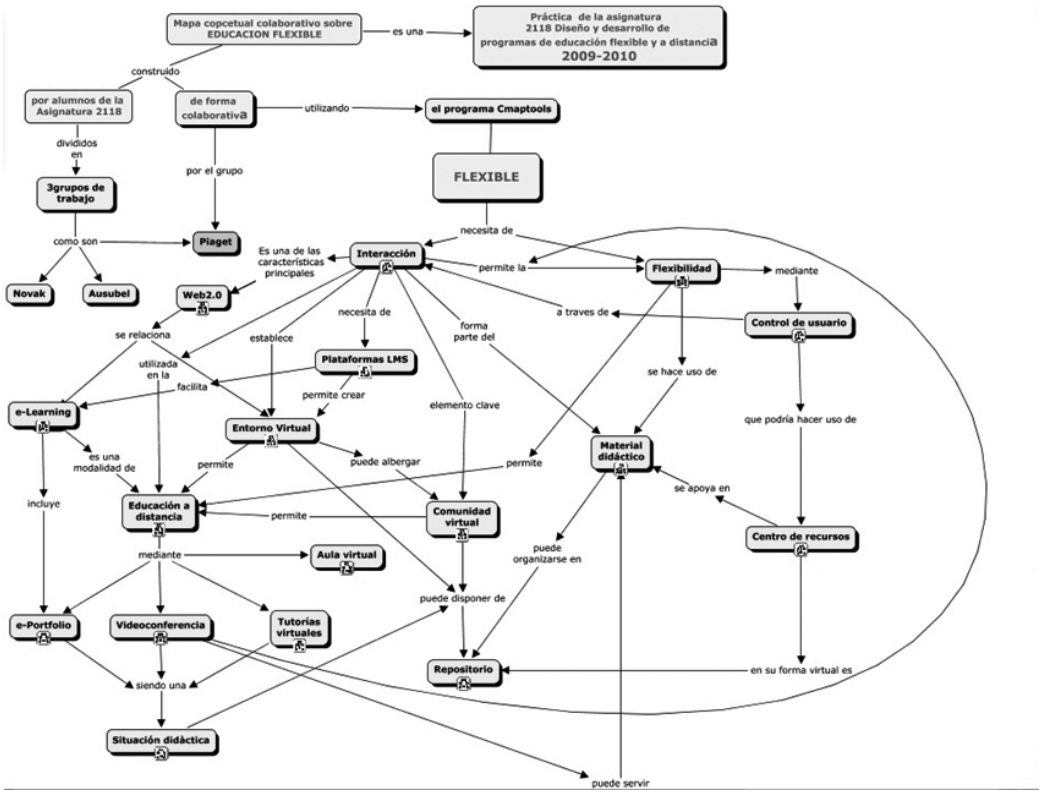


Figura 1. Mapa colaborativo definitivo de uno de los grupos

A partir de cada uno de los tres mapas, los estudiantes debían prepararse para la entrevista de evaluación. Para ello y de forma autónoma, siguieron diferentes estrategias:

- Estudiantes que simplemente trabajaron con el mapa correspondiente para preparar las cuestiones sobre aspectos conceptuales de la entrevista;

- Estudiantes que anotaron y marcaron sobre papel dicho mapa de forma que suponía una 'reconstrucción' del mismo;
- Otros construyeron su propio mapa conceptual de la asignatura a partir del mapa colaborativo, mediante reconstrucción y apropiación de la estructura de conceptos.

Queremos llamar la atención sobre la reelaboración de mapas conceptuales de la asignatura como un proceso personal de análisis, evaluación, elaboración y conexión que redunda en un dominio más profundo de la materia.

En el proceso de la entrevista de evaluación se preguntó a cada uno de los estudiantes por el proceso de estudio, reelaboración, etc.. sobre le mapa colaborativo. Un proceso que podemos considerar de reelaboración fue realizado por 1 de cada 3 estudiantes participantes. Dichos estudiantes obtuvieron, en general, mejores calificaciones que aquellos que utilizaron simplemente el mapa colaborativo para preparar la entrevista. Entendemos, sin embargo, que esto no es significativo, dado que tanto la reelaboración del mapa, como los logros de aprendizaje pueden deberse a una mayor motivación y a tener mejores expectativas respecto al curso.

En las Figuras 2, 3 y 4 pueden observarse ejemplos del trabajo realizado en la reelaboración respecto al mapa colaborativo de base. Puede observarse, por otra parte, que se produce un proceso de apropiación resultando en una clara diferenciación de los distintos mapas conceptuales.

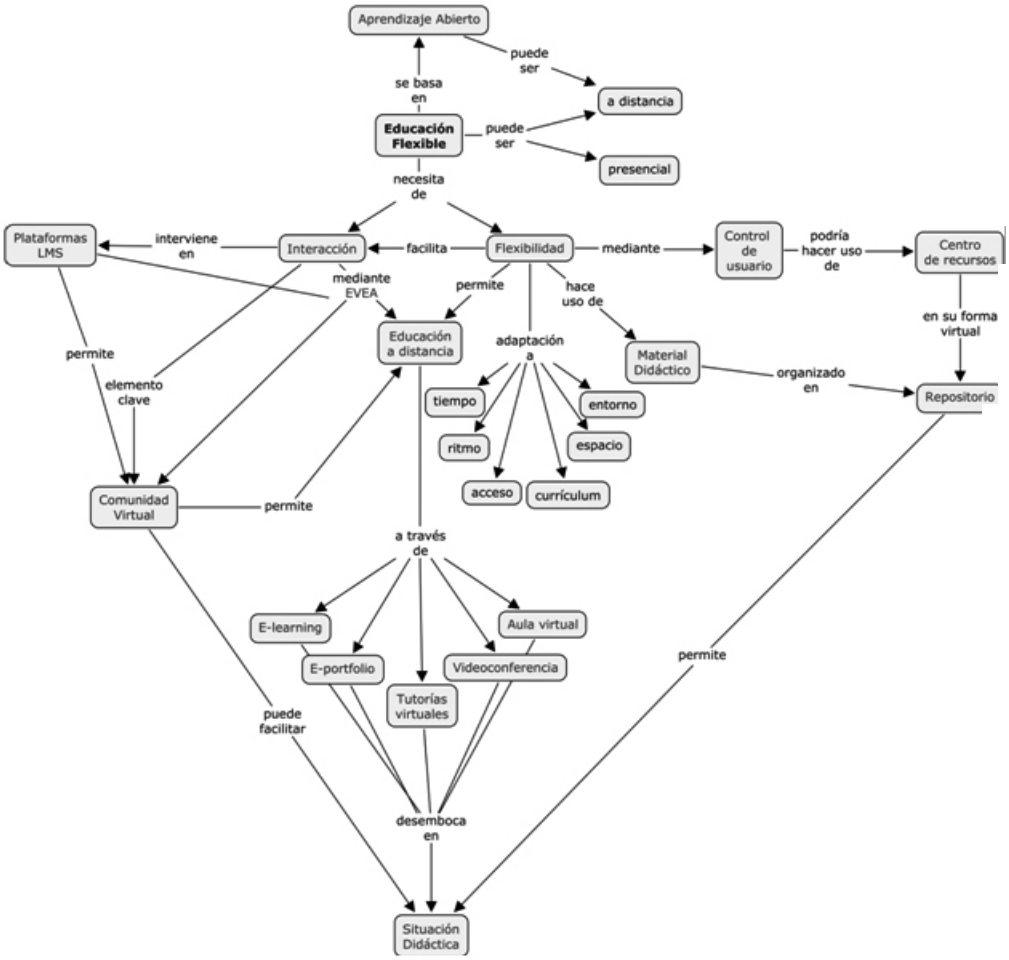


Figura 2. Mapa conceptual de la asignatura (reelaboración realizada por C.E.)

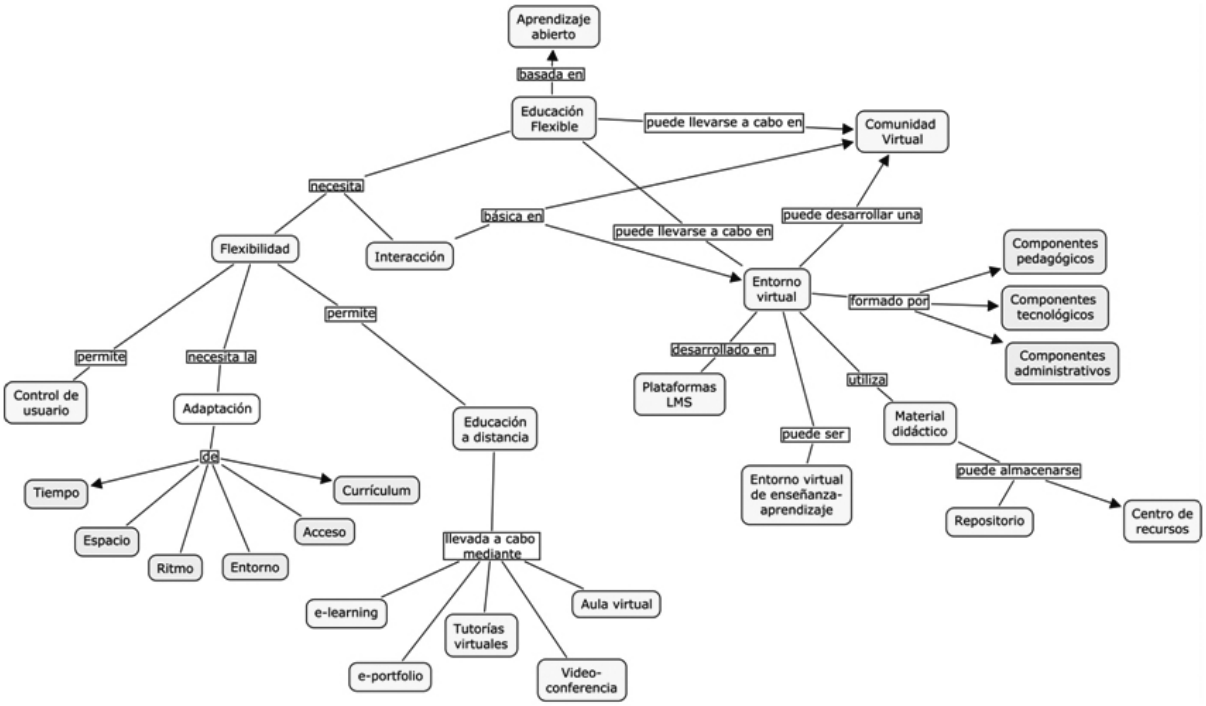


Figura 3. Mapa conceptual de la asignatura (reelaboración realizada por M.P.)

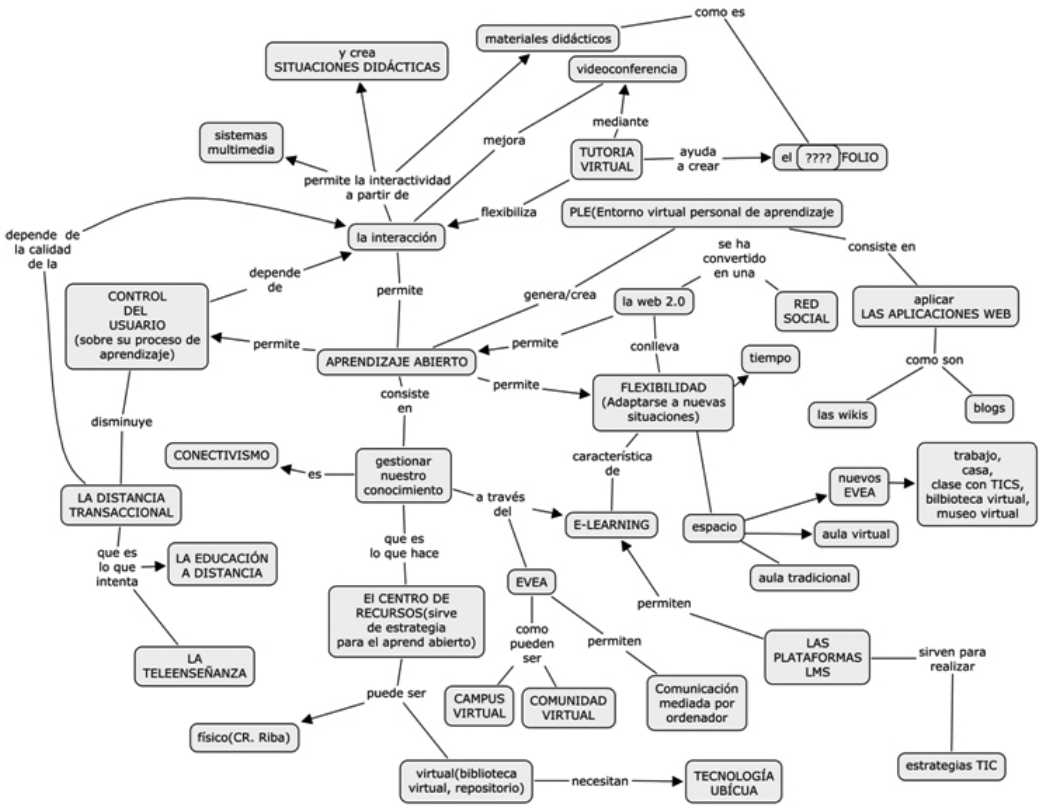


Figura 4. Mapa conceptual de la asignatura (reelaboración realizada por A.L.)

En el desarrollo de la entrevista de evaluación, pudo apreciarse que aquellas personas que habían reelaborado su mapa personal (sea utilizando CMaptools, sea sobre papel, etc..) mostraron mayor desempeño en aquellos problemas y cuestiones planteados en relación al mapa colaborativo y a la relación entre los distintos conceptos, etc, al mismo tiempo que mejores resultados de aprendizaje en términos de dominio conceptual de la materia.

Como se ha dicho anteriormente, se entiende que esto no es significativo, dado que tanto la reelaboración del mapa, como los logros de aprendizaje pueden deberse a una mayor motivación y a tener mejores expectativas respecto al curso.

5 Reflexiones

De la experiencia desarrollada podemos extraer una serie de reflexiones, en ningún caso definitivas.

1.- En relación al propio proceso señalar que, en general, los alumnos mostraron dificultades para trabajar de forma colaborativa, debido probablemente a la falta de experiencia en este tipo de actividad y lo que supone el trabajo en grupo y la realización de un proyecto en común (compartir el conocimiento, la calidad comunicativa, estrategias organizativas, intercambio de información,…). Uno de los problemas encontrados fue la insuficiencia de comunicación entre los miembros de alguno de los grupos, lo que provocó que algún mapa conceptual definitivo no tuviera una estructura coherente y clara para su posterior utilización como elemento didáctico. Esto quedó patente y fue compensado en la discusión en clase de los diferentes mapas.

2.- Los estudiantes han utilizado los mapas conceptuales utilizando Cmaptools para representar y expresar los modelos de cada concepto y para interrelacionar cada uno de los mapas conceptuales en un mapa colectivo, permitiendo la crítica constructiva y promoviendo la colaboración entre ellos. El alumno construye y reconstruye el conocimiento apoyándose en procesos de aprendizaje colaborativo. Este proceso se valora como una buena estrategia de aprendizaje respecto a la base conceptual del curso.

3.- Al tener que organizar los recursos mediante mapas conceptuales, el estudiante debe mostrar un buen dominio del tema (en este caso del concepto asignado y su posición relativa en la materia), lo que contribuye a mejorar el proceso de selección, asimilación, organización y expresión de elementos de Internet para integrarlos en su propio material, debiendo dedicar tiempo a la comprensión del concepto. El proceso tiene fuerte repercusión en la comprensión de la red conceptual.

4.- La crítica y discusión de los mapas de forma colectiva contribuyó a identificar errores conceptuales e incomprensiones. Al mismo tiempo, la utilización de mapas conceptuales como estrategia de aprendizaje y como procedimiento de evaluación fomenta la reflexión y el metaconocimiento del alumno sobre su propio proceso de aprendizaje, ayudándole a regular y controlar este aprendizaje. Por tanto, la construcción colaborativa del mapa conceptual fomenta, de esta manera, una reflexión conjunta y la corresponsabilidad del resultado final, competencias que contribuyen a mejorar el perfil de salida de la carrera.

5.- La utilización de los mapas conceptuales en los procesos de evaluación mediante entrevista contribuyen a comprobar el dominio conceptual y la comprensión sobre el complejo de conceptos ya que al interactuar con los mapas los estudiantes interiorizan, depuran e integran nuevo conocimiento. La representación visual permite al estudiante constatar el desarrollo de la propia comprensión integral y, eventualmente, comunicarla. En este sentido, hay que tener en cuenta que muchas veces el qué de lo que aprenden los alumnos depende mucho de cómo piensan que serán evaluados.

6.- La utilización de los mapas conceptuales en entrevistas de evaluación resulta congruente si se espera que los alumnos alcancen habilidades de pensamiento de alto nivel. También resulta congruente con las estrategias didácticas centradas en el alumno que son utilizadas como propuesta metodológica del curso y que, al mismo tiempo, se estudian como contenidos del mismo. Constituye un valioso criterio de referencia para el alumno, en cuanto al éxito o fracaso de la propia experiencia de aprendizaje y en cuanto a la calidad de dicha experiencia.

7.- La reelaboración personal del mapa conceptual puede identificarse con la función de instrumento cognitivo, ya que

desarrolla pensamiento crítico al abarcar el pensamiento crítico propiamente dicho (análisis, evaluación y conexión), el pensamiento creativo (elaborar, sintetizar e imaginar) y el pensamiento complejo (diseñar, resolver problemas y tomar decisiones).

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USING CONCEPT MAPS AS A SYNTHESIS TOOL TO CONSTRUCT INTEGRATED CURRICULUM

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Abstract. In this work we present the use of concept maps during the construction of integrated curriculums, facilitating teachers dialogue and fostering the understanding of the intricate relations between each element that must be considered to construct a curriculum. We describe our experience in curriculum design during the last years at Federal Institute of Santa Catarina, in Brazil.

1 Introduction

This paper presents the use of concept maps as a synthesis tool during the collaborative work to construct integrated curriculum at Federal Institute of Santa Catarina, in south of Brazil.

The concept maps are a kind of "graph" used to represent the relationships among a group of concepts. The concept maps were developed by Novak in the sequence of studies on meaningful learning model (Novak & Cañas, 2006). In the concept map representation, concepts can be represented in a hierarchical way with the most general and inclusive concepts at the top and the more specific ones organized hierarchically in the bottom. For a concept corresponding to a node, it is also possible to build another concept map with the objective of refining it.

The use of concept maps has increased during last years, in particular on educational activities. One common use of concept maps is to organize and structure the knowledge, for example in curriculum planning, showing the relationship between different parts of the course. With this organization of contents is possible to identify the general concepts prior to instruction and assisting in the sequencing of learning in a progressive way, from general to more specific and explicit knowledge (Novak & Cañas, 2006).

In this work, the concept maps were not only utilized to present the contents organization. They were used as a powerful collaborative and synthesis tool in each step of curriculum construction. We used concept maps to synthesize educational and legal documents about curriculum, facilitating the understanding and the discussion between the members of work group. We used concept maps to synthesize ideas during collective debates. We used concept maps to show innovative ideas incorporated in an integrated curriculum. Finally, we also used the concept maps to organize knowledge in each curricular unit.

As applications examples, we describe four different experiences in curriculum planning realized during the last years at Federal Institute of Santa Catarina, evolving different modalities of courses.

2 Concept Maps Applied to Organize Knowledge in a Curriculum Planning

The use of concept maps has been unproved in the last years at Federal Institute of Santa Catarina. The first experience was managed in 2005. In this year the concept maps were used to model a complete technical course for adult education in the area of refrigeration and air conditioning.

To start the process, we presented the meaningful learning model and we realized some workshops about con-

* All concept maps presented in this paper were translated from the original wrote in Portuguese.

cept maps with the teachers involved in the course planning. In the second step, a global concept map, describing the "scope of formation", was constructed in a collaborative manner and discussed by teachers and people of pedagogical support. The Figure 1 shows a concept map* that represent the scope of formation of the course of refrigeration and air conditioning.

Looking and referencing the global map describing the scope of formation, each teacher constructed a concept map of his specific discipline. Teachers of fundamental areas, like physics, mathematics and humanities also worked in this activity. Finally, all the concept maps were presented, discussed and modified by the group of teachers. The Figure 2 shows a concept map representing the knowledge organization of the HAVC (Heating, Ventilating and Air Conditioning) Design discipline, constructed by the a teacher of technical area of refrigeration and air conditioning.

In this application, the concept maps allowed a global view of the technological course and showed explicitly the relation between different disciplines involved in the educational process. The common points of these disciplines could be clearly observed by teachers, avoiding the superposition of contents and the omission of important ideas.

The concept maps also create a link that facilitated the communication among teachers. In each discipline, the concept maps also helped teachers to organize their modules and put in sequence the contents to be taught, according the meaningful learning model.

The set of concept maps were systematized and published on the web, forming a reference to the course development.

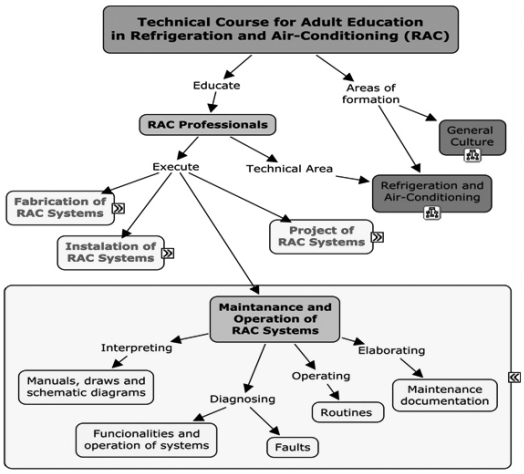


Figure 1. The scope of formation in the course of refrigeration and air-conditioning

3 Concept Maps Used as a Synthesis Tool to Construct an Integrated Curriculum

The second great experience in the use of concept maps in curriculum planning was during the design of a course to licentiate teachers in chemistry and physics.

The Federal Institutes are a traditional net of technical schools in Brazil, offering technical courses from basic to graduate level. The courses to licentiate teachers are a new modality of education that were recently incorporated to the Federal Institutes responsibilities with aim to decrease the lack of science teachers for basic education in Brazil (Brasil, 2008).

To construct a curriculum for this new modality of education was a great challenge to teachers of Federal Institute of Santa Catarina. To better prepare the group of teachers involved in the curriculum planning, the work initiated with formative activities in many areas related to curriculum and legal aspects of a course to licentiate teachers in science education. The first formative activity was about "epistemology" and "history of science", as tools to help the interdisciplinary studies in science education. We also discussed the use of "research as a formative tool" to improve

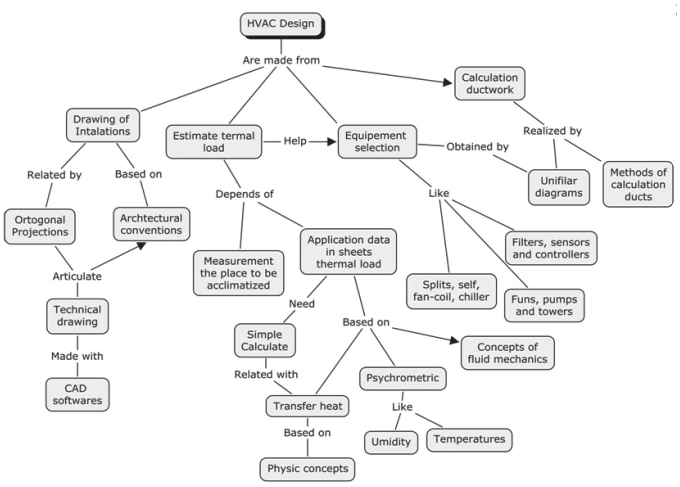


Figure 2. The concept maps representing the knowledge organization of the HAVC (Heating, Ventilating and Air Conditioning) Design discipline (Elaborate by teacher Jesué Graciliano da Silva)

learning and the relations between "practices and theory" in science courses (Chassot, 2008). In the second formative activity we discussed the Brazilian governmental polices to licentiate teachers and other legal aspects of this modality of education (Freitas, 2007; Machado, 2007). About curriculum planning we discussed the concept of "integrated curriculum" and we also realized some workshops about the use of concept maps in educational activities and curricular planning (Novak & Cañas, 2006; Cantú et all, 2004; Cantú & Farines, 2007).

During these formative activities, the concept maps were used to synthesize documents and ideas under study. We highlight that concept maps helped in documents understanding, showing the main elements in study, and facilitated discussion of subjects among people involved in the work group. An extensive set of concept maps were constructed and published on the web. Some concept maps were utilized in the pedagogic project of course and they constitute a base for consult and studies about the ideas used to uphold the curriculum. After these formative activities, we started the construction of the "professional profile" of the course to licentiate teachers of science. We realized many meetings and we used concept maps to model and organize the ideas under discussion. Using a multimedia projector and CmapTools*, the concept maps were constructed and discussed on line by the group of teachers. After each meeting, the concept maps were refined, systematized and published on the web, facilitating the feedback and preparing the next discussion. The Figure 3 shows a concept maps representing the professional profile of the course to licentiate teachers in science.

In the next step of curricular design, the work group began to construct the "curricular matrix" working in a collaborative manner. With a "free interpretation" of concept maps, many new educational ideas were incorporated in our "curricular matrix", which does not seem a traditional one, as is show in the Figure 4.

The left side of Figure 4 shows the three "thematic moments" that were divided the course. The first moment, in the two first semesters of the course, the theme is "to problematize the relationship between the student and school and the student and science". The second thematic moment, during the third and fourth semesters of course, is "study the possibilities of transform and improve the process of education". The last thematic moment, during the last four semesters, is dedicated "to make interventions on the pedagogic reality".

For each semester, a "core problem" was chosen to integrate the curricular units, as the right side of Figure 4

* Informations about CmapTools can be obtained at http://cmap.ihmc.us.

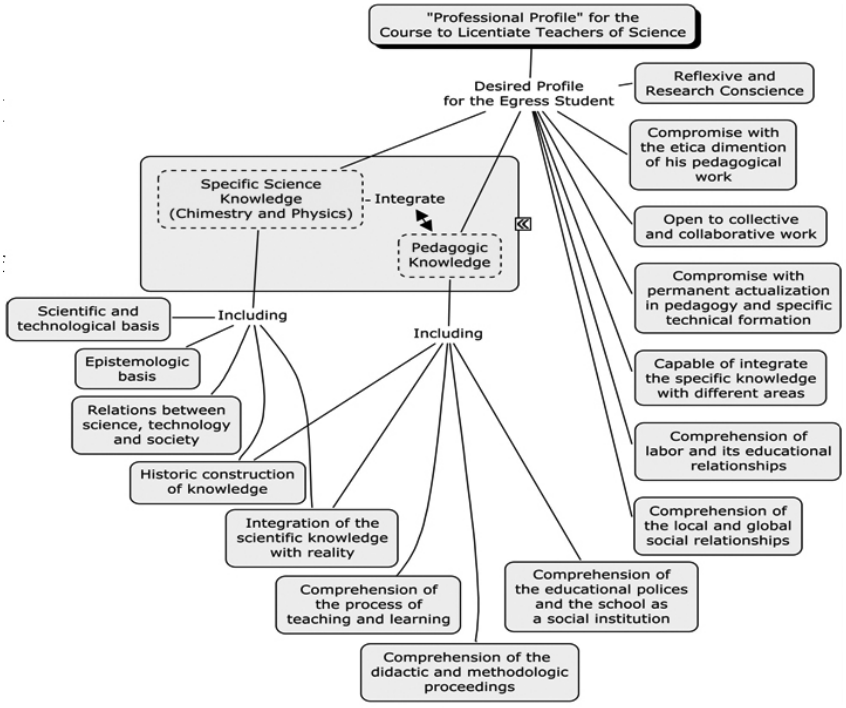


Figure 3. The desired profile of the egress of the course to licentiate teachers in science

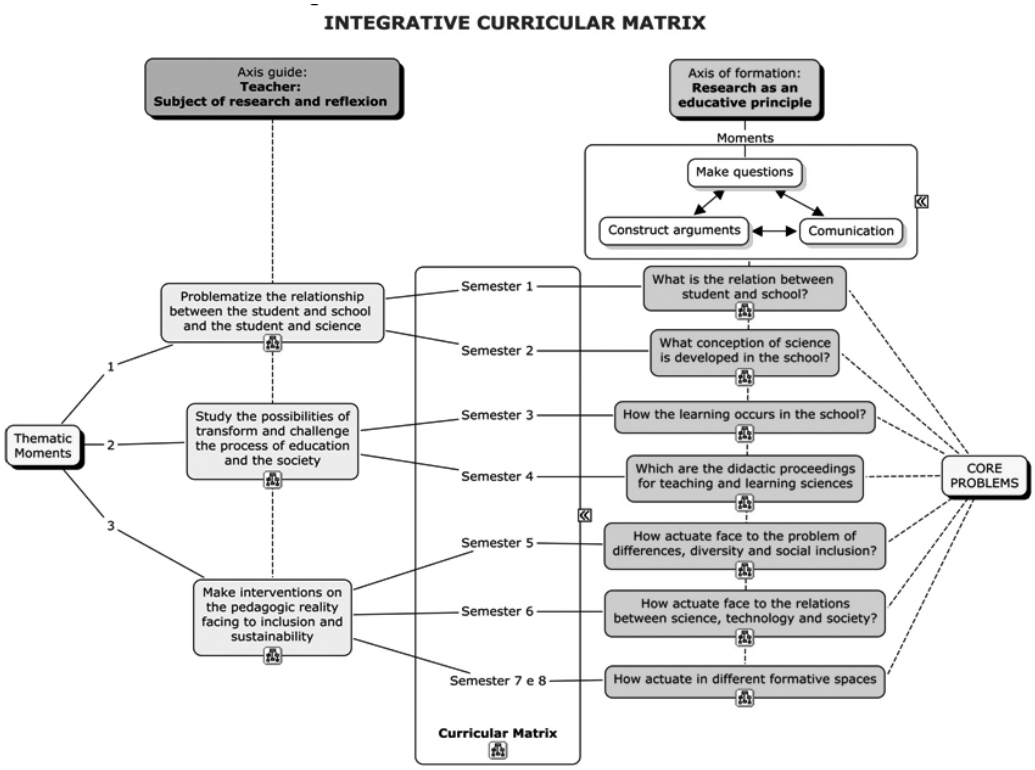


Figure 4. The curricular matrix of the course to graduate teachers

shows. These core problems are utilized as central questions in “integrator projects”, “professional stages” and “final

The Figure 5 shows the curricular units that form the first semester of the course. The “core problem” of this semester is developed through an Integrator Project, which integrate the curricular units of this semester. The teacher of each curricular unit must “answer the questions”, show at the right side of Figure 5, as a form of collaborate in the Integrator Project of the semester. Working this way, all teachers evolved in the curricular implementation know how to collaborate with others teachers in order to realize an integrated work. The curricular units other semester are organized of similar way and also modeled by concept maps.

All this educational ideas were modeled with concept maps, which were constructed on line by the group of teachers along many meetings using the CmapTools. These maps are now published on the web and support the implementation of the course to licentiate teachers.

4 Concept Maps: A Reference Tool to Manage a Collaborative Work

After these successful experiences of using concept maps in curriculum planing, described in the two previous sections, our academic community took the concept maps as a reference tool to manage collaborative work.

Recently, we used the concept maps to manage the collaborative work during two others curriculums planning. In the first work, we used the concept maps as a synthesis tool during the construction of a curriculum for a new modality of technical course for young people, integrating the studies of secondary school with a technical formation. In this work, we managed a group of 20 teachers, including teachers of technical domain and fundamental areas, like mathematics, physics, languages and humanities. Here we used the concept maps to synthesize documents and to represent the common ideas under discussion. The final project of the course included many concept maps used to represent the curriculum organization and key ideas.

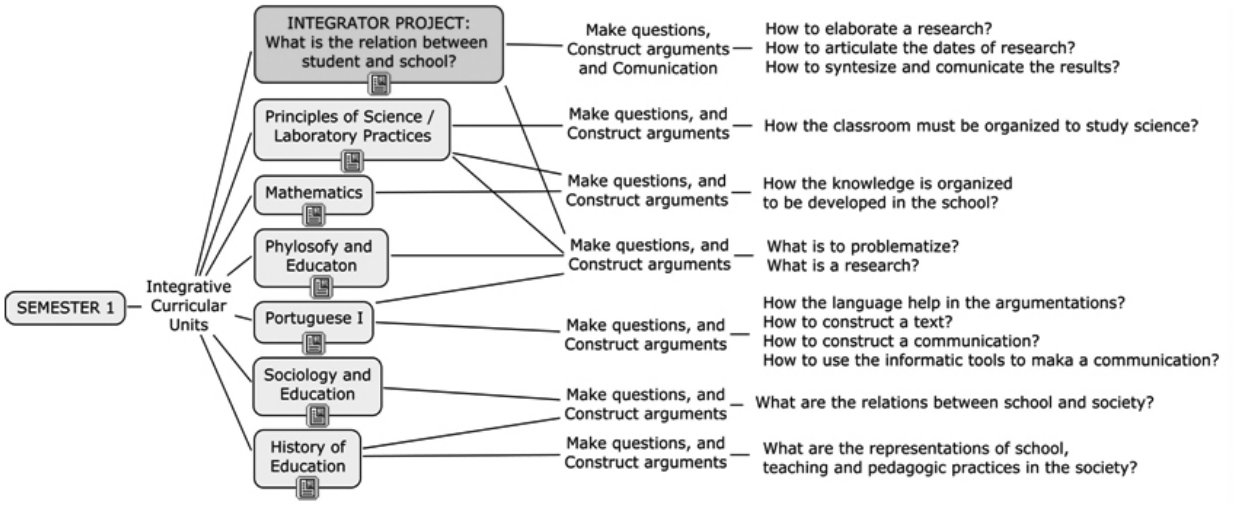


Figure 5. The desired profile of egress of the course to licentiate teachers

The last work is under construction, in which we are planning a curriculum for telecommunication engineering. The engineering courses are also a new modality of education that was recent incorporated in Federal Institutes responsibilities with the aim of improve the Brazilian development and decrease the social differences in Brazilian society. In the same way, we are using the concept maps as a synthesis tool during the collaborative works. Many documents with polices and principles for engineering courses for the Brazilian reality were modeled by concept maps and are published on the web. The Figure 6 shows one of a set of concept map constructed to represent the guiding principles of engineering courses at Federal Institutes (Brasil, 2009). These concept maps facilitate the understanding and the exchange of ideas among people involved in the curricular design for engineering. We highlight that people of different Campus of Federal Institute of Santa Catarina are using these concept maps to better understand the polices

and principles for engineering courses.

The "professional profile" of the course of telecommunication engineering is also been constructed with the help of concept maps. The profile includes many humanistic competences which will be develop during the course using "integrator projects" and "problem solving" strategies turned to solve social problem of the Brazilian society. All these ideas are under construction and we believe that concept maps will be a great help to construct the final curriculum.

5 Final Considerations and Perspectives

The experience of using concept maps as a synthesis tool during curriculum planning, makes us confirm some convictions about education and collaborative work.

First, the collaborative work is imperative to produce any pedagogic innovation and concept maps actuate to improve these innovations representing clearly the ideas under construction, encouraging the emergence of new ideas and facilitating the share of knowledge among people working together.

Second, the continuing education is fundamental to construct the personality of the educator. When people of different formations and open mind work together to accomplish some objectives many possibilities emerge and the work becomes a space of formation. Sharing knowledge and using a new tool, as the concept maps, the educators learn and improve his/her professional skills.

Last, as Novak and Cañas (2004) assert, the concept maps and the associated tools connected to Internet create a new model of education, putting in practice many educational ideas that were difficult to implement other way. Beyond the use of concept maps to improve the students teaching and learning, we emphasize the power of this tool to help teachers and coordinators to improve the educational activities, like the curriculum planning activities described in this paper.

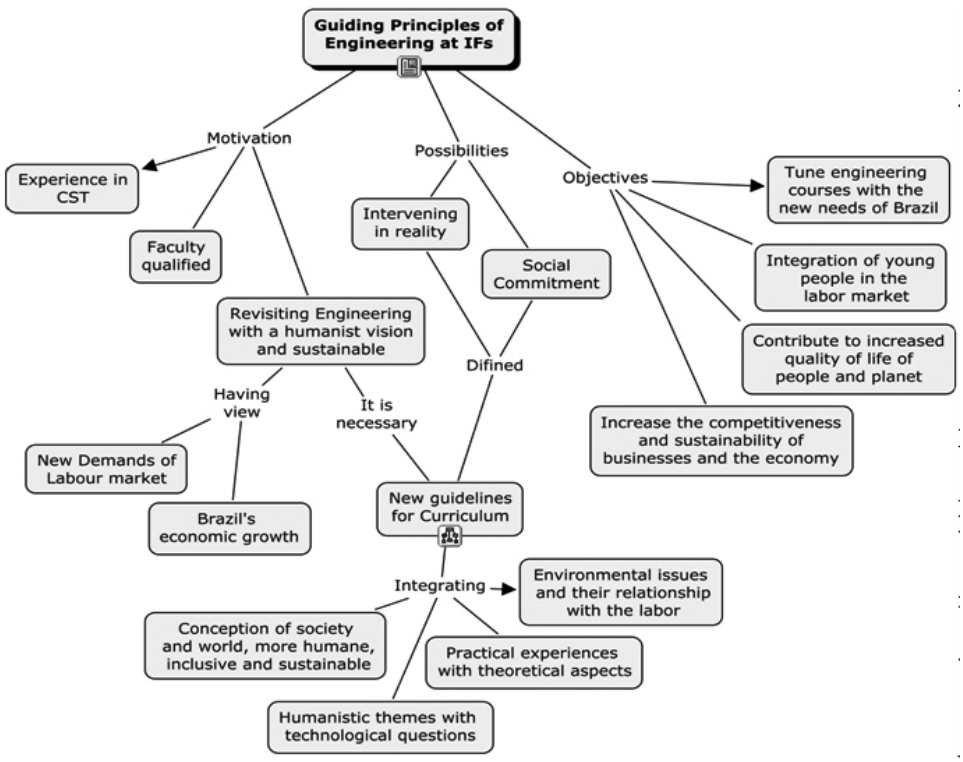


Figure 6. Guiding principles for engineering courses at Federal Institutes

6 Summary

In this article, we presented the use of concept maps as a synthesis tool during the collaborative work to construct integrated curriculum. We describe four experiences in curriculum design during the last years at Federal Institute of Santa Catarina, Brazil. In the first experience, the concept maps were used to describe the profile of course and to organize the knowledge in each discipline. In the other experiences, the concept maps were used as a synthesis tool during all phases of curriculum planning, to synthesize texts and documents, to organize and to share ideas and to model the final curriculum.

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WHAT IS A PHD? PROCESS VERSUS PRODUCT IN PHD SUPERVISION

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Abstract. This paper uses concept mapping and interview techniques to track knowledge and understanding among students and their supervisors in the course of full-time research towards a PhD. The on-going work measures both cognitive change in the specific subjects that are the topic for research and in the understanding of the process of PhD level research and supervision. The data makes a unique contribution to our knowledge of research processes and an understanding of lab-based science research supervision. It also helps to provide documentary evidence of the ways in which supervisors can act to facilitate learning and discovery. The challenges of a PhD being both a process of learning (for the student and the supervisor) and a product of a research project are explored. The approach comprises detailed case study analysis rather than any broad inferential comparison. Case studies are used to highlight the unique nature of relationships and supervisory practices, contrasting with literature on generic PhD supervisory styles and practices. This paper works to develop a research-led pedagogy of supervision that places the process and product of a PhD at the centre of the supervisory relationship. Supervision and supervisory styles cannot be analysed independently of the work that is being done.

1 Introductión

This project attempts to lay the foundations for the development of a research-led pedagogy for dissertation supervision in the lab-based sciences, e.g. molecular biology and biochemistry. Hetrick and Trafford (1995) and Salmon (1992) provide detailed analysis of the processes involved in PhD supervision, however both neglect to document the process through time and report instead, individual expectations of the supervisory role. Further research details various roles and styles of PhD supervision (Burns et al., 1999; Lee, 2008; Mainhard et al., 2009). The results indicate the importance of supervision as a process, but do more to highlight the need for future research than to explain exactly what this 'process' might entail.

Nevertheless no extant literature provides empirical data for such a journey through time and no studies to date have attempted to do this simultaneously among supervisor and student. As a result any attempt to formulate pedagogy for dissertation supervision lacks an underpinning research base. This is despite Salmon's (1992) consistent emphasis on the importance of change and the support for change in the course of research. Documenting knowledge and understanding among PhD students and their supervisors through the course of a PhD is key to understanding what the joint processes of research and of supervision entail (Brew, 2003). Recent theoretical and methodological developments in the fields of concept mapping (Novak, 2010) allow for a research and development tool for longitudinal use in the study and practice of PhD supervision.

This study builds on previous work (Kandiko et al. 2008) and follows four pairs of students and supervisors over the duration of a PhD. Through detailed case studies using concept-mapping and interview techniques, changes (or lack thereof) are tracked over time. All of the case studies are in lab-based sciences, an area of large expansion in PhDs and one that differs in many ways from traditional one-on-one supervisory relationships; this is discussed further below.

2 Background

There has been a recent policy focus on employment outcomes, skills formation and quality, the latter judged by completion rates, student satisfaction, and supervisory effectiveness (Pearson & Brew, 2002). This shifts the PhD from a time of knowledge creation to one of research training. This is contrasted by Curzon-Hobson (2002), who develops and defends a notion of trust in higher learning, and examines the pedagogical challenges of its pursuit within the sphere of higher education. It is argued that the experience of trust between teachers and students is a necessary foundation for a critical, dialogical learning environment, yet it is an endeavour that can be endangered by many of the demands and restrictions placed upon teachers in higher education. There is a general neglect for the support and

development of research skills (Roberts Report, 2002) and an overall lack of a research-led pedagogy for dissertation supervision. Despite this, there is literature supporting the importance of communication and collaboration skills in PhD education (Phillips & Pugh, 2005) and also on feedback on written drafts as a form of communication, a form of learning and a process of discovery (Kumar & Stracke, 2007).

There is a need for research that blends both qualitative and quantitative elements in the study of doctoral education (Crossley & Watson, 2003). Unfortunately, much of the research on PhD supervision is decontextualised, and universalises the supervision process—across types of enquiry, disciplines, countries, and individual characteristics (e.g. Delamont et al, 1998; Phillips & Pugh, 2005; Whisker, 2004). This literature suggests an idea that supervision can be analysed separately from the context of the specific PhD. Rather, we see supervision as inherently part of the thesis development and completing a PhD, therefore supervision and the supervisory relationship is unique to each PhD. However, there is a developing literature around grouping and typifying supervisory styles, often set around personality types and matrix divisions, discussed below.

3 Supervision styles and roles

In a study of 250 postgraduate students, Kam (1997) found there was "no set prescription" (p. 101) for a supervision style, and supervision quality and style was significantly affected by the needs of the students. Furthermore there is a push for students to take a more proactive role in supervision (Gurr, 2001). Burns et al. (1999) identified three typical or preferred ways that supervisors and students conceptualise supervision: thesis orientation, professional orientation, and personal orientation. Murphy et al. (2007) furthered Burns et al. (1999) work and came up with four orientations, with two distinctions, that can be organised in a matrix format:

- whether the supervisor should direct and take responsibility for the research (controlling beliefs) or should guide the process (guiding beliefs); and
- whether the focus of supervision should be more upon the research tasks to be completed (task-focussed beliefs) or upon the development of the candidates (person-focussed beliefs). (p. 219)

Issues arise when there misalignment of student and supervisory styles or expectations. Mainhard et al. (2009) developed a questionnaire based on interpersonal supervisor behaviour, developed along two axes (Opposition—Cooperation) and (Dominance—Submission) and eight types of behaviour: leadership, helpful/friendly, understanding, giving students freedom and responsibility, uncertain, dissatisfied, admonishing and strict. They map out both influence and proximity. They find supervisors face the most challenge in combining oppositional behaviours, such as supporting a students' research and dealing with a student failing to meet requirements and deadlines. From literature reviews and interviews with supervisors Lee (2008) developed five approaches to supervision:

1. Functional: where the issue is one of project management.
2. Enculturation: where the student is encouraged to become a member of the disciplinary community.
3. Critical thinking: where the student is encouraged to question and analyse their work.
4. Emancipation: where the student is encouraged to question and develop themselves.
5. Developing a quality relationship: where the student is enthused, inspired and cared for. (p. 270-1)

However increasing regulation in universities to try and increase pass rates has led to a focus on the functional aspects of supervision, leading conversations about the other dimensions to be done within a policy framework of upgrades, progress reports and thesis deadlines. Scholars have recommended individual student-based supervision strategies "those centred on the needs and aspirations of students based on their role expectations of their supervisor and the degree of responsibility they assume for themselves" (Kam, 1997, p. 101). However in practice, these categorisations are of limited utility in the process of supervision; there is utility in ignoring lists of traits and characteristics and focussing on what supervisors do and why (Cullen et al. 1994)

4 Methodology

Concept mapping (sensu Novak, 2010) is a method of graphic organisation. Its considerable utility stems from its origins within the human constructivist epistemology and it is now widely reported in the literature for use in the sharing of individual knowledge and understanding (Nesbit & Adesope, 2006). The concept mapping work of Novak and others has been used in studies of learning (Kinchin, 2001b); measurement of learning quality (Hay, 2007); PhD supervision (Kandiko et al., 2009); assessment (Edmondson, 2000); cognitive typology (Hay & Kinchin, 2006; Kin-

chin et al, 2000); learning style (Kinchin et al, 2005; Kinchin, 2004); and expert identification (Hoffman & Lintern, 2006; Kinchin, 2001a; Novak & Gowin, 1984).

In 2000, Kinchin et al published an important modification to the concept mapping method that encouraged a radically different approach to analysis. In particular, this work proposed a qualitative approach to concept map analysis based on gross structural morphology and it proposed a classification of map structures in three categories: spokes, chains and networks (Kinchin et al, 2000). These three typologies develop from chain to spoke to network designs. Since the publication of this work, this broad classification of map types has proven remarkably robust, and has now been documented among school children and adult learners, health-care professionals, and academic teachers (see Kinchin et al, 2000; Hay and Kinchin, 2006; Kinchin & Hay, 2005; Kinchin et al, 2005 and Kinchin & Hay, 2007 respectively). Furthermore, it is indicative of varying roles within the learning process at university (Kinchin, Lygo-Baker & Hay, 2008). Concept mapping can therefore be seen as an integrated mixed methodology.

Subsequently, the work of Kinchin et al (2000) has had considerable impact on our understanding of 'novice' and 'expert' status (Kinchin, Cabot & Hay, 2008). This is because the three basic knowledge structures (chain, spoke and network) have been shown to be synonymous with rote learning, the emergence of 'learning readiness ' and expertise respectively (e.g. Hay & Kinchin, 2006). Furthermore, the spoke, chain and network structures provide a theoretical framework for the measurement of emerging student expertise and the assessment of teaching and learning. This classification scheme has recently been scrutinised by Gerstner and Bogner (2009) who concluded that it "may be a good indicator of students' learning success," particularly when applied in combination with other testing mechanisms.

4.1 Multiple Case Study Approach

The identification of mutual conceptual development requires a research design that enables the supervisory process to be explored over time. The method chosen is congruent with our epistemological position, which relates to the legitimacy of generating data about how PhD students and their supervisors work together by talking interactively with them. The approach most suited to this position is qualitative, utilising what Charmaz (2001) calls "multiple sequential interviews" (p. 682); this type of interviewing "charts a person's path through a process" and creates the opportunity for a "nuanced understanding of that process." This can be enhanced through the application of concept mapping to offer additional insights into the richness of an individual's understanding (Kinchin, Streatfield & Hay, 2010). Four pairs of students and supervisors were recruited through Heads of Graduate Studies at a research-intensive university in the UK. All pairs are in lab sciences, although from a variety of Schools and disciplines.

4.2 Interview Procedure

In this on-going research, interviews are conducted with four pairs of students and supervisors and interviews are conducted separately to minimise the interference in the supervisory relationship. In-depth, semi-structured interviews are done with the students and supervisors at four-monthly intervals. Interview transcripts are translated into concept map summaries that provide structure for the data, facilitating analysis within cases and across cases. This also helps to identify a route through the developing narrative. Data collection and analysis occur at each stage, and enable each interview to draw upon the experiences of the participants to inform theory generation relating to changes in content and processes over time. The interviews explore two complementary lines of enquiry:

1. Topic – looking at the academic area under investigation within the PhD.
2. Process – looking at the conceptions held of the research process and of the PhD as an entity.

Questioning during student and supervisor interviews takes the form of three interconnected phases for each of the two themes. These three phases reflect the three phases of questioning identified by Pedrosa de Jesus et al. (2006) as 1) acquisition, 2) specialization and 3) integration. These in turn facilitate the co-construction of concept maps (by interviewee supported by interviewer) by building upon spokes, elaborating chains and finally integrating these as networks. This was guided by careful use of relational language (sensu Loewenstein and Gentner, 2005), during the interview to encourage the interviewee to make links explicit.

Furthermore, the simultaneous assessment of students and supervisors is important for understanding how the cognitive changes of one affect the other and vice versa. What for example are the consequences of new discovery by the student researcher on the extant knowledge structures of the researcher? Do these constitute new thoughts and

new ways of seeing things for both parties? Furthermore, will the active demonstration of change (or the lack of it) through concept mapping impede or enhance the rate of cognitive alignment towards new understandings of the field of research and possible of the research/supervision process itself? These important issues are able to be addressed through using concept mapping in the longitudinal study of PhD supervision.

4.3 Using Concept Mapping to Track Cognitive Change in Time

The work of Hay, Wells and Kinchin (2008) illustrates the power that concept mapping has to reveal the changes in individual knowledge and understanding that might occur through time. Despite this, however, reports of long term studies to reveal cognitive change are conspicuous, only by their absence. There is now a well developed literature on change in the course of learning. The arguments of Meyer and Land for example, are now widely cited in the literature on higher education teaching and learning (e.g. Meyer and Land, 2003). This work suggests that learning proceeds through a series of 'watersheds' in which failure to grasp 'troublesome concepts' arrests further change, but that once attained, these 'thresholds' represent new vistas for knowledge and understanding. Whilst 'change' is seen as the goal of education, and as an indicator of learning (e.g. Jarvis, 2006), it is the lack of change that may characterise many of our observations through time. Long periods of 'conceptual stasis' (Kinchin, 2010) have been predicted to represent the 'dominant state,' punctuated from time to time with rapid bursts of change as students pass through various thresholds. Concept mapping, in the way it is described here, affords an opportunity to subject this theory to empirical measurement.

5 Findings

Pair A shows the supervisor and student maps for the first research questions, about the topic of the student's thesis. Pair A (see Figure 1 and 2) highlights the differentiation of scope between student and supervisor in the conception of a PhD project. The supervisor focuses on the process and the student on the outcomes. The supervisor notes the connected process and student a question that needs to be broken down and solved in pieces.

The set of maps for Pair B are in response to the second question about what is a PhD. Pair B (see Figures 3 and 4) shows a difference between the supervisor and student in terms of seeing a PhD being about process versus outcomes. The supervisor map (3) concentrates on acts of doing and being, whereas the student map (4) focuses on learning and acquiring traits and characteristics. The supervisor's map (3) details the scientific process of discovery (through hypothesis testing). In contrast, the student's map (4) centres on publishing, the eventual outcome, but does not indicate the exact path to get there. The supervisor sees traditional scientific process at work, whereas the student has a much more pragmatic approach. This unique approach to assessing PhD supervision may allow for analysis of the role of 'expert' and 'novice' status in cognitive change, and over time the role of expert and novice may change. The act of mapping appears to surface underlying thoughts about PhD process and supervision. Mapping and interview techniques surface the highly unique and personal nature of the student-supervisor relationship.

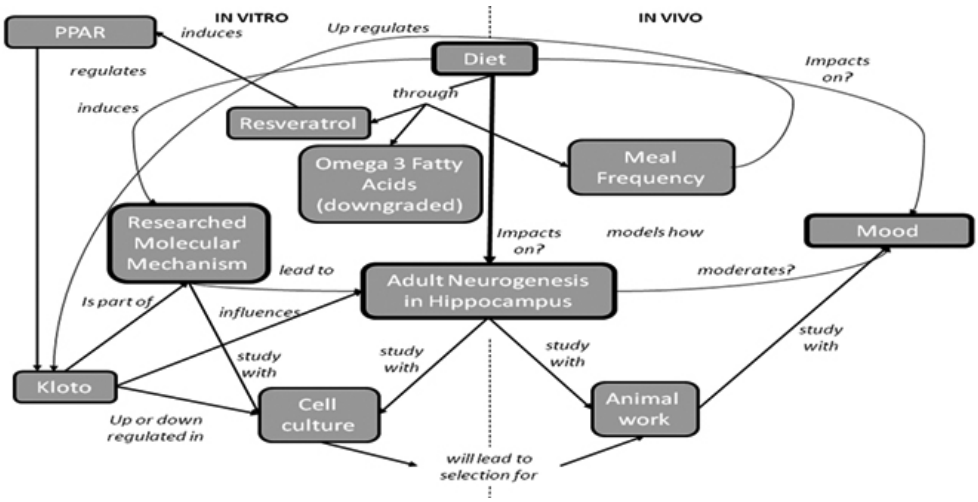


Figure 1. Pair A, Supervisor Map

6 Conclusions

There is more change in the relationship between the student and supervisor than change in understanding of the project, which seems to indicate long periods of conceptual stasis (Kinchin, 2010). This might be expected if a student's research project is seen only as development of a product to fit into someone else's life's work. In such a case, where a student is one of a large team and his/her thesis represents a contribution to a larger project one might question whether that "eureka" moment of critical insight is a required component of the thesis—or will be left to the supervisor after synthesising work from a number of theses to gain the big picture. Regarding the understanding of the topic, in all of the student maps there was a much stronger focus on the topic rather than the PhD process.

There was little change in the supervisor maps overall, with one supervisor asking, "why would these maps ever change." Perhaps for the supervisor, he or she has already passed the threshold of understanding and is not actively seeking additional thresholds to pass in the way the student is.

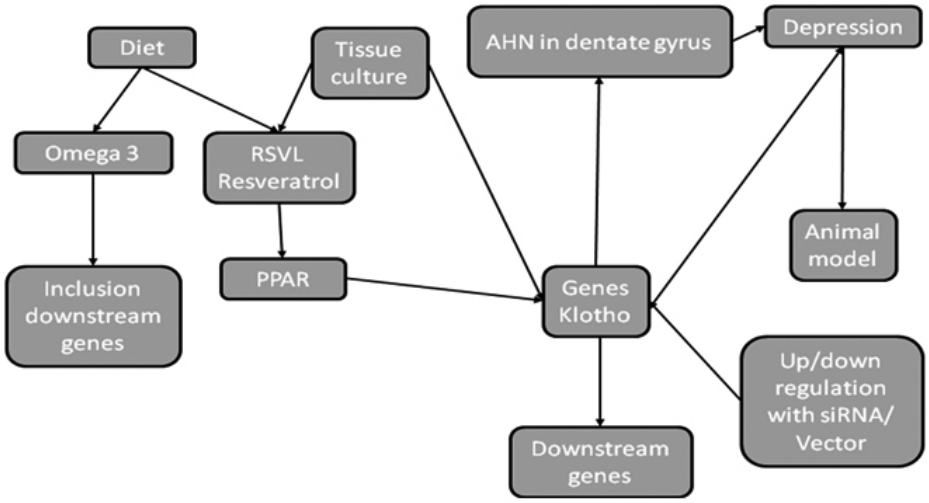


Figure 2. Pair A, Student Map

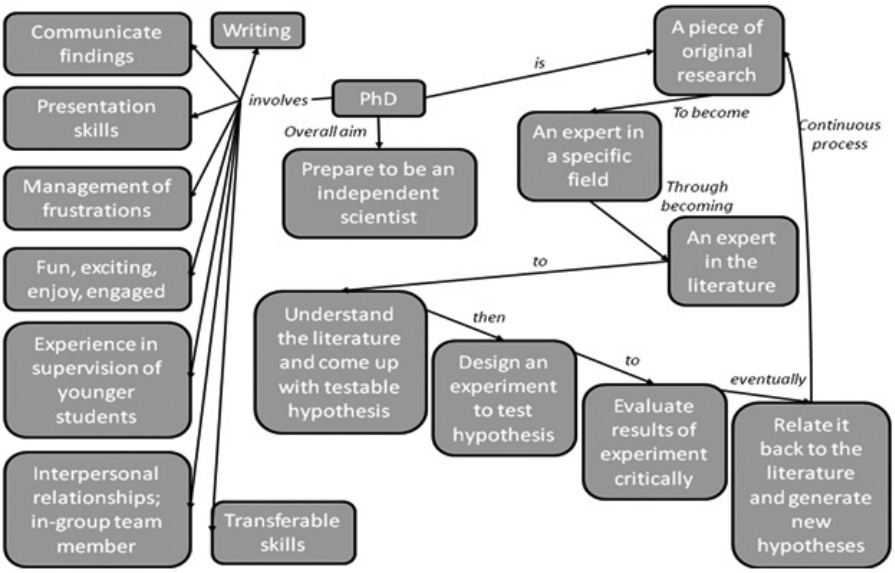


Figure 3. Pair B, Supervisor Map

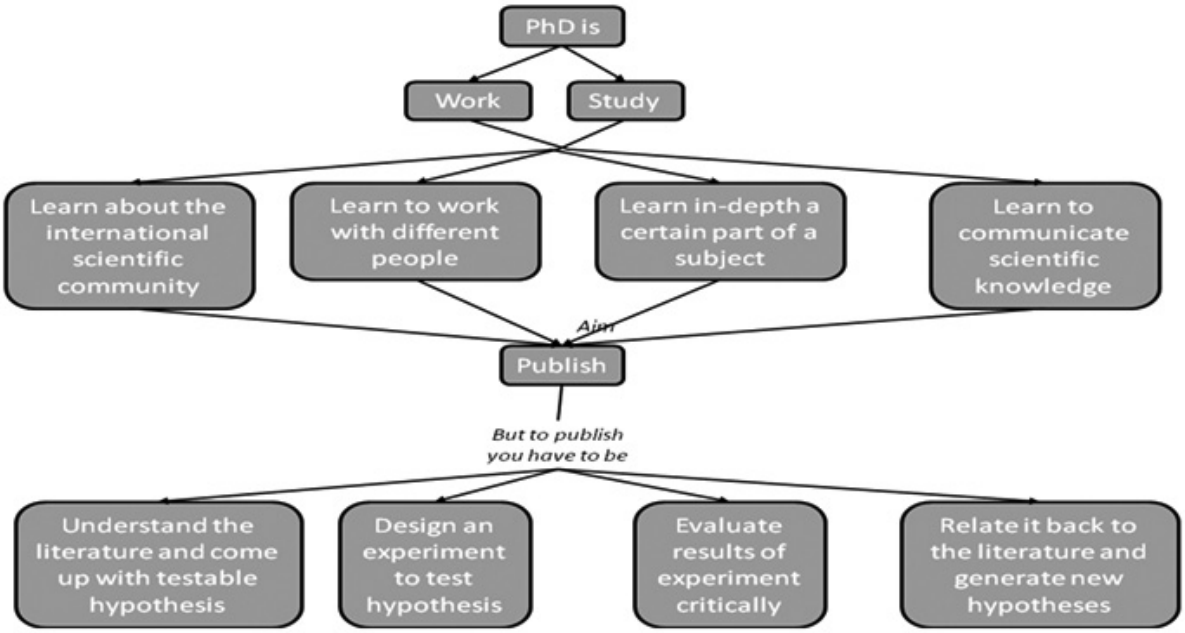


Figure 4. Pair B, Student Map

In terms of understanding of process, the PhD process was more important for supervisors who were trying to get students thinking critically, which often led the student to go against suggestions or advice given by the supervisor. However, the degree that this was actually allowed is debatable. Supervisors indicate that they try to inculcate students into the larger disciplinary community and develop students as scholars, but students often just want to get their work,(i.e. their thesis) done. One student commented, "I don't know why my supervisor keeps asking me what I am doing socially and how I am feeling. It is like she wants to be my friend—I would like her to just tell me what to do and stop giving me extra work." For students, the thesis is central; this raises an issue of process versus product.

These maps show the essential role of the thesis in the supervisory relationship and the supervision process. There is an ideal of a Golden Age of PhD education of students entering a lab full of busy scientists and after three years of learning on their own the students leave with thesis and all the skills they need. Now, as part of the accountability regime that has surrounded the thesis, to the extent that ironically the thesis seems to get in the way of the development of understanding and "the ability to become a scientist." This raises a question of how the thesis can be positioned, or repositioned, as on object of learning, development and understanding in the relationship between the student and supervisor.

In contrast to a Platonic empty vessel theory of learning, PhD supervision involves a mutual intellectual engagement that has been previously described as an "intellectual courtship" (Kandiko & Kinchin, 2009). However, the degree of involvement and sharing varies dramatically across case studies and disciplines. The case studies are used as examples of how the thesis is central in the supervision process, along with emergent issues of trust, learning and working styles, and the changing nature and purpose of the PhD. Product (thesis) needs to be part of the process (supervision). There is a need to make the thesis a central part of a research-led pedagogy for PhD supervision, rather than concentrate on supervisory styles and roles.

It is important for this research that the data illustrate particular cases of cognitive change and show patterns of stasis and change. Furthermore, the simultaneous assessment of students and supervisors is important for understanding how the cognitive changes of one might affect the other and visa versa. What for example are the consequences of new discovery by the student researcher on the extant knowledge structures of the researcher? Do these constitute new thoughts and new ways of seeing things for both parties? Furthermore, will the active demonstration of change

(or the lack of it) through concept mapping impede or enhance the rate of cognitive alignment towards new understandings of the field of research and possible of the research/supervision process itself? These are important issues that are able to be addressed through the teaching of conceptual change using concept mapping in the course of research.

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USING CONCEPT MAPPING AS A NOTE TAKING TOOL TO COMPUTER SCIENCE

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Abstract. First-year studies in higher education indicate the future success in studying. Particularity in the field of computer science the first two to three years seem to be critical. Adjusting to academic studying settings seems to be difficult for many computer-savvy young people, and, on the other hand, the successful students are drawn into business life at early stage of their studies. In order to prevent drop-outs several interventions to the curriculum were initiated. One of which was Studying Techniques as an obligatory module in an introductory course to computer science. The module consisted of four themes with individual and group assignments. One of the themes addressed note taking techniques and students were introduced to concept mapping. The purpose of this study was to find out, how useful the students in computer science found concept mapping in note taking during lectures or studying in general. The data rests on written assignments by the students. In this article, we evaluate the student experience of concept maps in the light of their reflective group essays. The results indicate that many students found it easy to take notes graphically by hand or using CMapTools, but on the other hand, the rhythm during the live lectures was of the found too hasty for map drawing. Coming back to the notes afterwards and going though them before tests were found useful.

1 Introduction

In this article, we highlight the student experiences in using concept maps in their studies. The assignment looked into was about note taking techniques and the student were asked to use concept mapping to take meaningful notes from lectures. The collected data rests on reports by the student study groups. In these documents the students explicate how useful or unusable these newcomers in computer science found concept mapping in note taking during lectures.

Note taking techniques can be divided roughly into two categories: Non-linear and linear note taking techniques (Makany, Kemp & Dror 2009, 621). Concept mapping is one of the non-linear techniques along with, for example, mental mapping (Buzan 2010). Examples of linear techniques are Cornell Notes (2010) and traditional bullet points.

In a recent study by Makany, Kemp and Dror (2009, 633-634) the underlying cognitive mechanisms behind effective note taking and knowledge representations were assessed. As a result, students using the non-linear note taking learning strategies seemed to overall increase their academic performance through deeper understanding and highly integrated knowledge management. Participants with such learning strategy represented information in a semantically more connected and meaningful way than their peers with traditional, linear note taking strategy.

According to Piolat, Thierry and Kellogg (2005, 297, 303) note takers have tackle several problems related to the flow of information, particularly when taking notes from lectures. They must maintain an active representation of what they are hearing in order to get sufficient time to exploit and to transcribe a portion, while being faced with a continuous updating of the message content as it is spoken. Piolat et al. point out clearly, that when listening, more operations are concurrently engaged and, thus, taking notes from a lecture places more demands on working memory resources.

2 Background and Setting of the Course

Department of Computer Science at the University of Helsinki is well-known for its high quality research and tuition. During the recent years, the department has gained twice the status of the Centre of Excellence in Finnish University Education by the Finnish Higher Education Evaluation Council Constant research and development of studies, curriculum development, study guidance and putting student feedback to use are providing high quality, constructively

aligned frame for studies (Computer Science Research 2007, Hiltunen 2009).

However, the student engagement in studies is a constant worry of the staff. The experience and research results indicate that approaches to studying are often surface oriented and the students find the following tuition and instruction difficult (Biggs & Tang 2007). In computer science the first two to three years seem to be critical. Adjusting to academic studying settings turns out to be difficult for some computer-savvy newcomers, and, on the other hand, the successful students are drawn into business life at early stage of their studies. In order to prevent drop-outs, several interventions to the curriculum and study guidance have initiated. One of these is the two European Credit Units Studying Techniques. This course was embedded in an introductory course on computer science and the students attending the course were starting their first year of studies. However, many of them had gained experience on studying in other higher education institutes, like polytechnics, or they returned back to their studies after several years in business life in order to gain official qualifications.

The studying during the Studying Techniques course was organized as follows: the head, the senior lecturer in computer science, was in charge of organizing the course and addressing the key issues and objectives. He also gave study guidance to the students and took care of the building up a network of assistants, who were responsible for their own student groups. The weekly agenda consisted of one lecture, one study session guided by the assistants and co-operation in small peer groups of three to four students. The lectures introduced the core concepts of computer science and the development of the discipline. The students in the same peer group met on a regular basis in between the supervised lectures and study sessions. Several of the assignments were organized in order to encourage the students to works co-operatively. Each peer group was in charge to present their ideas and finding on some of the topics in the guided study sessions at least once during the course. The teachers gave feedback and the issues were discussed vividly during the group sessions.

The studying techniques module of two European study units (about 55 hours of student work) was embedded in an introductory course of computer science (4 European study units). The learning objectives of the Studying Techniques were planned to guide the students to taking studying seriously. The most important underlying outcome of the activities, however, was to help the students to acclimatize themselves into the cultural atmosphere and conditions of the department and the science campus. All learning assignments were stored on Moodle platform. The course consisted of traditional lectures in computer science accompanied by three shared lectures by the authors of this paper. These lectures included instructions and discussion about study skills and general information about time management, academic writing, ethical questions and their self-evaluation about their studying skills etc. additionally. The themes of the Studying Techniques module were as follows:

- Self-evaluation of approaches to studying
- Introduction to academic writing
- Note taking techniques
- Reflective summary ‘What did I learn?’

In this paper, we concentrate on one of the learning assignments with the non-linear note taking tools.

3 The Data Collected and Methods Used

The data for this study consists of 30 joint reports of the peer groups. All together the enrollment rate was about 100 students, but due to the change of plans, drop-outs and crediting previous studies etc., there were 76 students actively engaged in this course at the end of the autumn term 2009.

The reports were compiled by the peer groups and documented on a Wiki site with links to the concept maps and linear note taking assignments. The instruction of the task was to attend lectures and take notes using non-linear techniques, like concept maps or mind maps. The other task was to take notes using text based linear techniques, of which the Cornell Notes (2010) was introduced as an example. The instructions were given orally during the lecture and in a written form on the Moodle platform. The instruction session was summarized by pointing out ‘seven golden rules’ for concept mapping (Kinchin, De-Laij & Hay 2005, 3). This was done because many of the students were familiar with mind mapping, and we wanted to encourage the students to use active verbs in their maps:

1. Concept labels are written in boxes

2. Major concepts appear at the top of the page and more specific concepts appear
3. Each concept can only be written in one place on the map
4. Links have arrowheads to show the direction in which they should be read
5. Links must have labels (words or phrases) to give them meaning
6. There can be any number of links coming from or going to a concept box
7. Do not include so many concepts that the overall structure becomes unclear.

The research questions were as follows:

- How useful did the students in computer science find concept mapping?
- What kind of arguments the reserved students have against concept mapping?
- How did they apply the seven rules of concept mapping in their notes?

In order to answer these questions, the reports were analyzed using qualitative content analysis and interpretation (see, for example Cresswell 2003, 190-197). We figured out what kind of learning strategies and approaches to learning the students applied while testing the use of concept maps in real studying settings.

4 The Results

4.1 Student views about concept maps in note taking

The positive reflections reported by the students indicate, that the non-linear note taking was, at its best, inspiring and motivating:

This task was the most useful for everybody absolutely so far! 'Furthermore, it was funny to be at last able to make the buttocks of the perpetual in practice in the chair, and nose in display … After the notes we did not only learn new methods to cope with the lecture but we also learn something also from the studying techniques suitable to ourselves.

Meta-cognitive skills were pointed out by many of the respondents. Repeating for exams and understanding ‘the bigger picture’ was mentioned in several reports. Concept mapping was, however, often found challenging especially during the lecture:

It was evident, that one lessons learned or pointed out was the need to come back to the notes taken after the lecture and complete and improve them. This was obvious especially in concept maps, because the rhythm of the lecturing prevents the students to rethink what they are up to during the lessons.

Also this task was uncovered itself valuable. When doing this, we had once again to ask ourselves questions of the matters which are very important from the point of view of the studying. The self-evaluation of own ways of operating is the first step for the improvement of the operation and in this case the first step towards the more efficient studying. When studying, these matters neither will necessarily become thought itself nor notice "to update its own habits”. It also is nice to see in a peer group the other students' comments on the matter.

In the concept map the problem section is the fact that it cannot be directly used in connection with the lecture but it has to be drawn up only when all material is already in the head. On the other hand, it also operates excellently in the examination it is handy to write up with its relations the sectors which are related to the question and to see – on the basis of my own experiences, something essential is missing.

4.2 Reserved and negative experiences in concept mapping

The cognitive effort and the severe time pressure of note taking during the lectures compared with the note taking from books or text in general was recognized by some groups. Note taking requires that information is both quickly comprehended and recorded in written form. The note taker has to both comprehend the message of the lecturer and produce

a new written product at the same time. From books and articles, this process is easier. The following quotes illustrate the student experience similar to these research findings by Kinchin (2005) and Piolat, Thierry & Kellogg (2005, 306):

It is probably easier to make the concept map based on the text because it can be directly processed after having read the text. But the concept map will be challenging for taking notes because the building of the concepts and chains between them requires exact attention. Of course it would be ideal to supplement and to specify notes after the lecture, but in reality there is not much time for such working in addition to all the exercises and tasks of the courses.

The mindmap looked good the first hour of the lesson, but then I tried to connect the different ideas and the mess occurred quite suddenly and as a result I lost interest in taking any more notes. I looked at the two lines I had written in the upper left corner and abandoned the technique immediately...

Using information technology and computers was quite common among the students

I myself experienced the drawing of the concept map a difficult and time consuming way to make notes. My train of thoughts will not go when I am forced to think about the layout at the same time. Even though I regard myself as the human being visually directed, I get a better understanding about a well-arranged text than from a concept map.

The concept maps and mind maps are suited best for visual people who learn more effectively with the help of pictures. I myself am not one of this types and I get easily confused with concept maps and mind maps.

4.3 Style of the concept maps

The visual images of the concept maps produced by the students' notes were drawn both by hand and computer. The most common digital tools were CMapTools and Buzan's (2010) mind maps. Compared with the list of golden rules of concept mapping (Kinchin, De-Laij & Hay 2005, 3), the concepts were almost always written in boxes, but major concepts did not usually appear at the top of the page. More of than not, the major concepts were placed in the middle of the map (Figure 1). Usually, each concept was written only once in one place, but the links occasionally had arrowheads. The links were labeled with active verbs irregularly, but they were used purposefully. More often than not, many concepts were used and the outlook was somewhat confused.

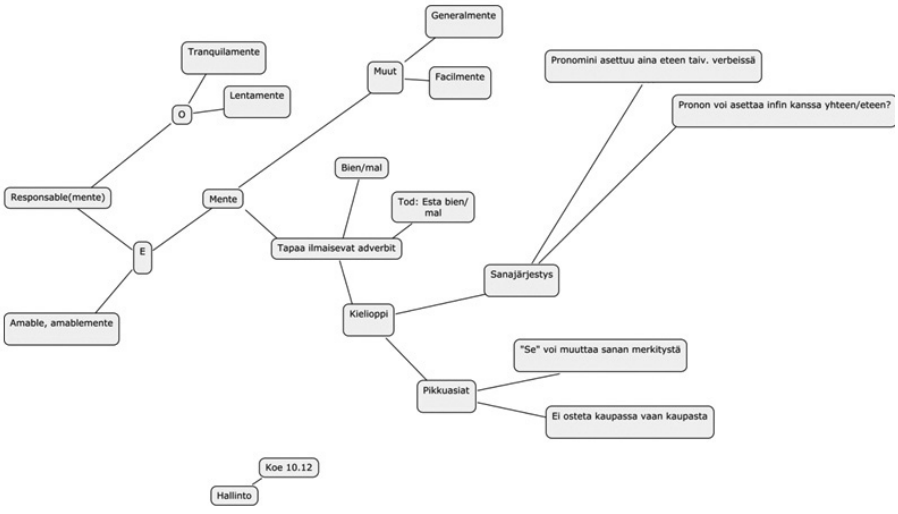


Figure 1. The student took notes by hand during her Spanish lesson. She redrew the map using CMapTools and used Spanish and Finnsih in her map, but did not want to use verbs in the links. Also the arrowheads are missing. The map indicates, that the student did not pay a lot of attention to the task. However, she marked important matters in her map. The two separated boxes in the left hand corner include a note on date and place of the exam. [Shall be translated later]

As was pointed out by Kinchin, Hay and Adams (2000, 46) the usual emphasis on valid links with active words and arrowheads seems to fail to recognize the significance of students' perspective. The invalid links in a map drawn by a student may reveal interesting processes of thinking along a particular path of understanding. In our case, quite similar evidence was found (Figure 2 and Figure 3) with explanations:

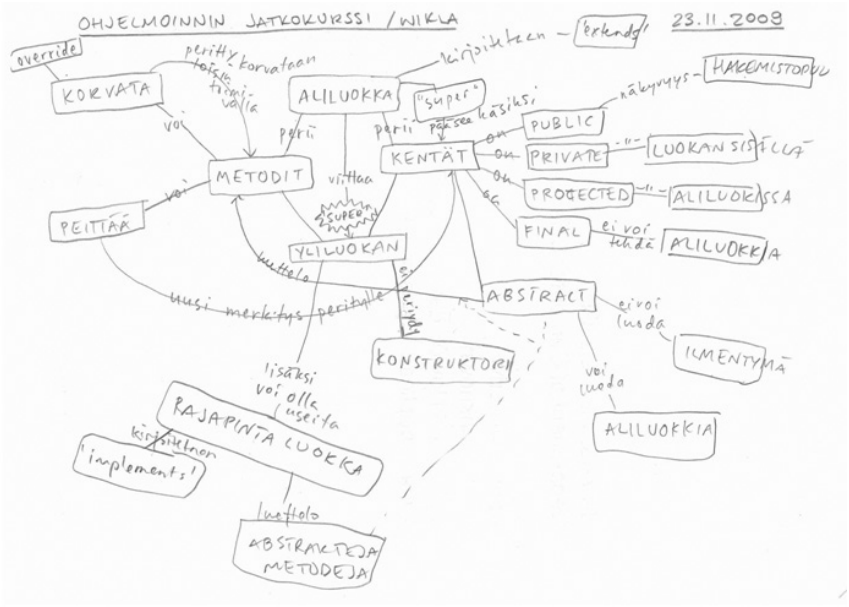


Figure 2. The student's concept map is about programming. He has used English and Finnish in his map. The links are valid and active verbs are used properly, but arrowheads are often missing. The map indicates, that the student has a coherent understanding of the topic. [Shall be translated later]

During the introductory course for computer science I made notes in the form of the concept map. It is not very functioning technique from the point of view of the learning to me because I concentrate on the clear appearance of the figure too much. I have no time to concentrate on understanding the substance and I end up only copying the concepts from the lecture transparency into my map. Afterwards nothing can quite be learned from the figure because the copied concepts are not at all clear to me. Also otherwise it is difficult for me to perceive new, big thematic entities from the graphic notes in which matters and arrows are swarming crosswise to the tick.

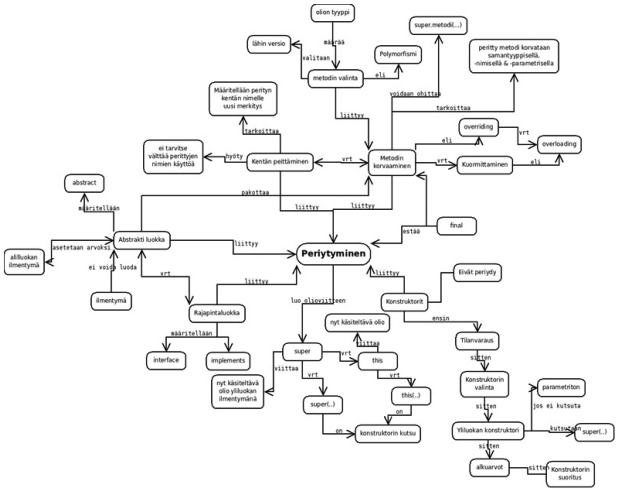


Figure 3. The student's concept map is bioinformatics. The key concept 'inheritance' is placed in the middle of the map. The links are valid and accompanied by arrowheads and active, relevant verbs. The map indicates, that the student has an excellent understanding of the topic. He used Finnish and English in the concept boxes [Shall be translated later]

5 Conclusive Remarks

In our study it was not possible to evaluate, how successful the students using non-linear note taking techniques were in their studies after this course. Research results in Makany's, Kemp's and Dror's study (2009, 633) indicated, that non-linears achieved better performance results not by recording significantly more details of the presentation but instead by putting concepts and examples into a semantically more connected network of mental representations. This suggests that non-linear note taking has a cognitively more optimal knowledge management system than traditional note taking. It allows the non-linear users to integrate the newly acquired pieces of information better into their existing network of mental representations.

In our case it was evident, that students found concept mapping challenging especially during the lectures. This finding was similar to Nordell's (2009, 41) study. She ran an Advanced Study Technique Workshop with student from several disciplines. According to the final assessment survey, only 6, 6 % of the students (N= 68) responded that they would modify or add to their studies making and using concept maps. Concept mapping was second the last on the list, while creating quizzes was the very last of the most implemented activities.

For further development of quality in learning for understanding the instructions for the course should include a wider implementation process of non-linear note taking techniques. For example, notes could be taken from the scientific papers already available as the material of the course. This process was depicted by Kinchin (2005, 74-75). In two of the figures by Kinchin there were annotations used in concept maps in order to raise questions among the students and by that way engage the students with the core substance of the article. Our results indicate that this annotation tool is worth adapting to facilitate the peer-to-peer co-operation and documenting in the study groups.

Additionally, however, there was a hidden agenda behind this note taking assignment. The purpose Not only to introduce concept mapping and share the experiences in the study groups, but also force the students attend lectures more actively. In this, we were quite successful and are going to further develop this leaning activity as part of our Study Techniques module.

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