

International Conference on Intelligent Computing, Communication & Convergence
(ICCC-2015)

Conference Organized by Interscience Institute of Management and Technology,
Bhubaneswar, Odisha, India

Concept Mapping in Education and Semantic Knowledge Representation: an Illustrative Survey

Raghavendra Katagall^{*}, Rakesh Dadde^{*}, R H Goudar^{*}, Sreenivasa Rao^{}**

^{*}Dept. of Computer Network Engg. (CNE), Visvesvaraya Technological University, Belagavi-590018

^{**}SIT, JNTUH and MSIT, IIITH, Hyderabad

rkk4691@gmail.com, rakeshdadde@gmail.com, rhgoudar@gmail.com.

Abstract

Concept Maps are graphic representations of topics, ideas, and their relationships. They allow users to group information in related modules so that the connections between the modules become more readily apparent. Among the potential uses of concept mapping for the improvement of learning and teaching in classrooms, the powerful technique of concept mapping could improve education in four different categories: (1) as a planned learning strategy, (2) as an instructional strategy, (3) as a strategy for planning curriculum, and (4) as a means of assessing students understanding of science concepts. Concept Maps are essential to increase meaningful learning in students and for representing the knowledge, experience of individuals and teams in education, science, medical and management course. In this paper we have made exhaustive survey to bind up various research works carried on concept maps in the above mentioned disciplines and have simplified the things for beginners to carry out research on concept mapping.

© 2015 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Peer-review under responsibility of scientific committee of International Conference on Computer, Communication and Convergence (ICCC 2015)

Keywords: Ausbel's Learning Theory; Meaningful Learning; Mind Mapping, Cmap Tools;

1 Introduction

Concept maps are graphical tools created by Joseph D. Novak and his team at Cornell University in the

1970's. These concept maps are based on Ausubel's learning theory². This technique has been used by many disciplines to organize and represent knowledge and enhance meaningful learning. Concept maps stimulate the generation of ideas, and help improving one's own creativity. They include concepts usually enclosed in circles or boxes of some type, and relationship between these concepts denoted by a connecting line linking to concepts. Words on the line represent the linking phrases. The roots of concept mapping arise from Ausubel's theory of meaningful learning. This theory was produced after Ausubel's work on how learners learn large amount of useful information from textual and verbal inputs.

Number of advantages of the use of concept maps for educational purpose are supplied by some prominent authors:

- Differentiation among essential and nice-to-know outcomes by users.
- Themes will be easy to discover.
- Sets way for thinking.
- Key concepts belonging to more than one discipline can be identified.
- Concept map provides a basis for discussion.
- Conceptual relationship used for intended program and course outcomes can easily be explained.

Concept maps are represented in hierarchical fashion with the most inclusive, most common concepts at the top of the map and less common concepts hierarchically below. Concept maps have a distinct advantage over many other types of instructional strategies when it comes to supporting higher order thinking skills. Creating of concept map requires a clear understanding of how ideas are related to one another and cognitive skills that cannot be accomplished simply through memorization or even the use of heuristics.

2 Literature Review

A number of studies are conducted using concept mapping as a pedagogical tool in all the discipline including Medical, Science, Education, and Management course etc. 17 researches are used in this section spanning from 2008 to 2014. The following subsections summarizes those researches in various disciplines,

2.1 Concept mapping in science subjects

In Jorge Villalon et.al³, proposes that concept maps acts as scaffolding by making conceptual understanding visible at different stages of the learning process for both undergraduate and postgraduate students. Paper throws light on Concept Map Miner (CMM) which is used to generate automatically concept maps from student's composition. The challenge for using Concept Map (CM) is time consuming and expensive. CMM is an automated tool for constructing concept maps and identifies concepts and their relationships. CMM can be integrated to e-learning environment. Concept Map Miner tool supports writing activities by scaffolding author's reflection during the process of writing. At last authors concluded that using CMM, students can easily generate concept maps from composition, and they can discuss its design and implementation.

In A.M.M et.al⁴, Authors stated that manufacturing is knowledge intensive activity. As we all know that the Internet can help us to create Internet Aided Manufacture (IAM) using concept mapping. This paper tells the interplay between IAM and Cmap. Cmap is an effective means for representing existing knowledge as well as representing new knowledge gained from existing knowledge. Knowledge in IAM is categorized as General Knowledge (GK) [Description], Exploratory (ExK) [analysis, laboratory work, documentation], Emergent (Emk) [critical thinking] [GK Union ExK]. Using Cmap tool we integrate GK, ExK, EmK and represented in IAM. Knowledge is not the reality as it is but logical or perceived interpretation of it. The explanation namely evidential ordering and eliminatory explanation on that are useful for formulating emergent knowledge from Exploratory and General Knowledge. Cmap is used in representing knowledge underlying complex engineering problems.

In Yingying Jiang et.al⁵, proposes a kind of context aware hand drawn concept map with RFID tags, which is especially useful for pan based mobile devices. In the proposed method first the structure of the hand drawn concept map is extracted and then users can assign RFID tag to concept nodes. Authors finally suggests that their proposed method of concept maps improve the traditional concept maps in the following aspect.

- It adopts hand-drawn concept map which is natural.
- The representation ability can be enhanced by RFID tags.
- RFID tags could be used for retrieval of concept nodes as well as hand drawn CMs.

In Susan M. Zvacek et.al⁶, an experiment is carried on engineering students, who do well in memorizing large

amount of information, the ability to use that information for complex problem solving, critical thinking or creative activity remains limited. Paper discuss how CMs can be used for instruction and then describes a pilot project how to integrate concept maps into a course in mechanical engineering, the preliminary results of their activity and recommendations based on these result, authors mention the following steps to construct CM,

- Identify the central topic
- Brainstorm a list of ideas
- Organize the concept visually
- Link the concept

Finally authors examines that students who use CMs in their homework and laboratory sessions score more on almost all measures of the final grading scale than those who were exposed to concept mapping only in few theoretical lectures.

2.2 Concept mapping in Education

In Chei-Chang Chiou et.al⁷, an experimental study was carried on 124 participants who were enrolled for advanced accounting course at the school of management in Taiwan. Author examines whether concept mapping can be used to help student to improve their learning achievement and interest and also observes significant improvements in learning achievements compared to traditional expository teaching method. The students were satisfied with the Meta learning strategy of concept mapping, which could be helpful in improving the skills. The paper concludes by proposing a change of method from 'transfer of knowledge' to 'learning to learn'.

In Gul Tokdmir et.al⁸, proposed a method to present course curriculum. University/Institutes or Organization have faced many problems such as diversity of the concept given in course. It is very difficult for students to see the picture of computer engineering domain. Similarly it is difficult to prepare course content in an integrated manner at the students' level. The 4 years of Computer Engineering program consists of both hardware and software issues. With the aid of concept mapping tool it is easier to build better concept relationships among theory and practice as well as among other concepts that are in the course. Concept mapping tools helps the learners build a relationship between previous knowledge and newly introduced concepts, encouraging meaningful learning rather than rote learning (memorizing concepts, new relationship to previous learning). Finally to build connections between the concepts taught in computer engineering course, new paradigm called 'Goal-Question-Concept' inspired from a well known GQM (Goal-Question-Metric) method of software engineering field is proposed in the paper.

In Grag Lammers et.al², paper visualizes about the conceptual understanding attained by students in the area of parallel computing. A small group of students was selected to create a concept maps that illustrates their understanding. Paper concludes that, students show a wide variation in their abilities to represent parallelism concept in a concept map. Several map scores of students have been evaluated by engineering faculty and it is observed that students faced difficulty in understanding the difference between parallelism and concurrency. At last author recommends a shift to a performance oriented approach which may yield benefits in expanding the rate of student knowledge.

In Martin Davies et.al⁹, proposes how software mapping tools are used for a number of education related purpose. These tools are used to impart critical and analytical skills to students, relationship between concept and method of assessment. All these tools use diagrammatic relationships. This paper outlines various type of mapping techniques available and their advantages and disadvantages. Firstly it defines mind mapping as visual, non-linear representation of ideas and their relationships. Mind maps are principally association maps. Authors found mind mapping could be advantageous as it is easy to remember a diagram than to remember a description. The demerit of mind mapping is that the types of links being made are limited to simple association. Secondly concept mapping is defined as more structural and less pictorial representation of known knowledge. The aim of concept mapping is to outline relationships between ideas thus concept mapping is relational device. Mind maps and concept maps differ in the level of precision and formality. The main drawback of concept mapping is that they require some expertise to learn. Lastly it defines argument mapping which is concerned with explicating the inferential structure of arguments. Unlike mind mapping and concept mapping, argument mapping is interested in the inferential basis for a claim being defended and not the casual or other associative relationships between the main claim and other claims. The paper concludes that the choice of a given mapping tool largely depends on the purpose or aim to which the tool is

used. Paper also suggests that these tools may well be converging to offer educators as yet unrealized and potentially complimentary functions.

In Lauri Lahti et.al ¹⁰, an experiment was conducted on students of introductory java programming course to draw concept maps representing technology about topic programming. Authors analyzed the drawn concept map in respect to the learner's self evaluation about amount of earlier programming experience, and the complexity of the concept map that is drawn is measured with five point likert scale. Paper aims to augment traditional wiki technologies for creating, editing and applying knowledge in learning based on data base of collaborative contribution supplied with user profiles.

In Gwo-Jen Hwang et.al ¹⁶, an experiment has been conducted to evaluate the effectiveness of the approach on students learning performance, learning satisfaction and cognitive load in an elementary school social studies course. The results show that the concept map integrated approach can significantly enhance the student's web browser approach in solving a problem. The students show lower degrees of technology acceptance and learning satisfaction in comparison with the conventional web based problem solving approach. Authors found that students in concept mapping group revealed higher cognitive load than those in the control group. As a consequence authors concluded that the integrated concept mapping and web-based problem solving approach is helpful to students in guiding them to learn in a more effective way.

2.3 Concept mapping in management courses

In R.Kavitha et.al ¹¹, authors brought up the need for e-learning, due to advancement in information and communication technology. Paper suggests that, for achieving adaptivity in learning, predefined concept map is used to provide proper guidance. The prerequisite concept relationship is often used to provide teachers for further analyzing and finding the teaching strategies and to generate up to learning guidance in adaptive learning environment. Paper proposes 3 phases in concept mapping, Phase 1- used to pre-process the testing records, Phase 2- is used to construct and transform the minded association rules into prerequisite relationship between quizzes which are non reluctant and noncyclical, Phase 3- the relevance degree between concepts in each quiz is found which forms the basis for construction of concept map. Thus the created CM can be used to develop adaptive learning system and define learning strategies.

In Vivian Gomes da Silva ¹², paper throws light on the way in which CM's have incorporated information about their creation and intended use and can be integrated into repositories functional learning objects. Author developed case study for requirement elicitation of Meta data structure that was then used in a web based software tool integrating a CM's authorizing tool and a learning object repository.

In Fabian Kneissl et.al ¹³, authors defined concept maps as the tool for supporting the learning process in as much that they make learners aware of their own progress. Paper proposes a game like e-learning tool named Termina to be used for assessing learners. The CM's are built from the association that the students provided through participation in Termina sessions. Termina's data gathering process is described and method for generating concept maps from the data gathered. Furthermore an exemplary concept map generated during the beginning of a university course is evaluated.

2.4 Concept mapping in Medical

In M.J.H Van Bon Martens et.al ¹⁴, authors suggested that the concept mapping is used as a method for developing the solution for complex problems, wherein the concept maps acts as guide to plan for complex topics. Study on concept map gives a better way to understand the practical knowledge and scientific knowledge in order to improve the theory. Five Dutch research fellows were given the task for serving different fields in public health. The main goal of these researchers was to construct a theoretical framework for good regional public health reporting, to design and implement strategies for integral local health policy, guide the evolution of a local integral approach of overweight and obesity in youth, to guide the construction of a questionnaire to measure the quality of post disaster physiological care, and to conceptualize and for formulation of ambitions and targets for the new youth health care programmer of regional health services. This study shows theory development can be improved through concept mapping, using concept map we can integrate the practical and scientific knowledge with careful selection of the topic from different research areas. Concept map create the best relationship between these different areas and the resulting concept map is best for practical decision making.

In Heather M.Hanson et.al ¹⁵, authors define how concept mapping could help in the area of preventive medicine. The main objective of this paper is to create a walking routine for elders which keeps them fully active and engaged

for whole day. In order to do this, authors have worked on to see how the elders behave with local environment and how it influences their priorities. Finally authors found that elders walking priority areas identified included sidewalks, crosswalks, and they finally concluded that the element which built social interests in environments will influence walking behaviour of the elders.

In Roshanak Mehdiapanah et.al¹⁷, studied the perception of a group of neighbourhood residents towards a large-scale renewal program in Barcelona and to explore its effects and importance on them we will be using concept mapping methodology. Author found that the majority of urban renewal projects within the initiatives, including improved walk ability construction of new public spaces and more community programs have positive and important effects. On the overall well being of participants paper presents an innovative method that diverts from traditional outcome-based evaluation studies often used within the field.

3. Tools for creating Concept Maps

This section lists some of the notable concept mapping and mind mapping applications which are available.¹⁸

i) CMAP Tools:

Used as a tool for creating concept maps. CMAP is developed by the Florida Institute for Human and Machine Cognition (IHMC).

ii) Coggle :

It is a Freeware mind-mapping web application. Coggle produces hierarchically structured documents, like a branching tree. This contrasts with conventional collaborative editors, like Google Docs, which provide either linear (text document), or tabular (spreadsheet) document formats. Its authors promise that it will be "free forever". Coggle supports export to PNG image and vector PDF formats.

iii) Compendium:

It facilitates the management and mapping of ideas and arguments. Compendium explores thoughts and illustrates various interconnections among different arguments and ideas. It is used as a tool for group of people to work in a collaborative manner to convey ideas to each other using visual images.

iv) Docear:

Docear is supposed to integrate a word processor, PDF editor and academic search engine. Docear lets import PDF annotations (bookmarks, comments and highlighted text). This way, a document's most important information can be easily organized. If more information is required than the bookmark or comment itself provides, Docear can open the PDF on the page the bookmarks points to. All information is structured in a mind map. Information management in a mind map is more effective and efficient than using a simple list or social tags.

v) FreeMind:

FreeMind provides extensive export capabilities. FreeMind allows editing a hierarchical set of ideas around a central concept. It assists in brainstorming new outlines and projects. FreeMind is Java application and portable across multiple platforms and retains the same user interface.

vi) Freeplane :

Freeplane is used to create mind maps and electronic outlines. Freeplane maintains partial file format compatibility with FreeMind - Freeplane fully supports the FreeMind file format. It Adds features and tags not supported by FreeMind which are ignored on loading.

vii) MindMup:

MindMup is released under the MIT License, and the source code is available from GitHub. MindMup is also available as a free anonymous web service at mindmup.com. Enables users to store maps on several cloud storage providers, including Google Drive, Amazon S3 and GitHub and collaborate in real time with other users.

viii) SciPlore MindMapping:

First mind mapping tool which integrates mind mapping with reference management .It enables the import of PDF bookmarks. The software is compatible with file format to FreeMind 0.9.

ix) WikkaWiki:

It is a Lightweight and standards-compliant wiki engine. Designed in PHP, uses MySQL to save pages. It is developed for speed, fine-grained access control, extensibility, and security.

x) VUE:

Visual Understanding Environment (VUE) project aims to create flexible tools to manage and integrate digital resources in support of learning, teaching and research. VUE gives a flexible visual environment for presenting, well structuring, and to share digital information. Students and faculties can design semantic networks of digital resources drawn from digital libraries, local and remote file systems.

xi) XMind:

The software can capture ideas, clarify thinking, manage complex information, and promote team collaboration. It supports mind maps, Ishikawa diagrams, organization charts, tree diagrams, spreadsheets and many more. XMind is used for managing tasks and organise knowledge. Export the mind maps into Microsoft Word, PowerPoint, Excel, PDF, FreeMind and Mindjet MindManager documents in XMind pro edition.

4. Conclusion

Concept maps plays significant role in understanding complex problems in a much better way. This paper presents the study of theoretical foundation and origin of concept maps, and also describes various approaches used in different disciplines like science, education, management and medical, and also highlights the advantages. Concept maps can be further enhanced for designing unified curriculum, question paper automation system and other fuzzy associations.

References

- 1 Pablo Ruiz-Palomino and Ricardo Martinez-Canas. Concept mapping as an innovative tool for the assessment of learning: An experimental experience among business management degree students , *Educational Research and Reviews* Vol. 8(22), PP 2187-2192,23 November 2013.
- 2 Greg Lammers and Cordelia M. Brown. Exploring students understanding of parallelism using concept maps *Frontiers in Education Conference (FIE)*, 2012 .
- 3 Jorge Villaon and Rafel A. Calvo. Concept Maps as Cognitive Visualizations on Writing Assignment *Educational Technology & Society*, 14 (3), PP 16–27, 2011.
- 4 A.M.M. Sharif Ullah, N.arai and M. Watanabe. Concept Map and Internet Aided Manufacturing 8th CIRP Conference on Intelligent Computation in Manufacturing *Procedia CIRP* Volume 12, Pages 378–383, 2013.
- 5 Yingying Jiang, Feng Tian, Hongan Wang Guozhong Dai. Combining hand-drawn concept maps with RFID tags *Proceedings of IEEE CCIS* 2012.
- 6 Susan M. Zvacek. Visualizing Understanding with Concept Maps 15th International Conference on Interactive Collaborative Learning (ICL), 2012.
- 7 Chei-Chang Chiou. The Effect of concept mapping on students' learning achievements and interests *Innovations in Education and Teaching International* Vol. 45, No. 4, PP 375–387 November 2008.
- 8 Gul Tokdemir, Nergiz Ercil Cagiltay. Concept Map Approach for Introduction to Computer Engineering Course Curriculum *IEEE EDUCON Education Engineering - The Future of Global Learning Engineering Education* 2010.
- 9 Martin Davies. *Concept Mapping Mind Mapping and Argument Mapping What are the Differences and do they Matter?* Springer Science Business Media B.V. 2010
- 10 Lauri Lahti. Concept map wiki-collaborative framework for agglomerating pedagogical knowledge 11th IEEE International Conference on Advanced Learning Technologies 2011.
- 11 R. Kavitha, A. Vijaya and D. Saraswathi. An augmented prerequisite concept relation map design to improve adaptive in e-learning *Proceedings of the International Conference on Pattern Recognition, Informatics and Medical Engineering*, March 21-23, 2012.
- 12 Viviane Gomes da Silva. Work in Progress: A Semantic Annotation Scheme for Concept Maps *IEEE Frontiers in Education Conference* Oct. 3, 2012 to Oct. 6, 2012, PP:1-2 .
- 13 Fabian Kneissl and Francois Bry. Fostering Concept Maps awareness as a means to learning *IEEE Third International Conference on Cloud and Green Computing* 2013.
- 14 M.J.H. van Bon-Martens, L.A.M. van de Goor, J.C. Holsappel, T.J.M. Kuunders, M.A.M. Jacobs-van der Bruggen, J.H.M. te Brake, and J.A.M. van Oers. Concept mapping as a promising method to bring practice into science *Public Health* 2014 .
- 15 Heather M. Hanson, Claire Schiller, Meghan Winters, Joanie Sims-Gould, Philippa Clarke, Eileen Curran, Meghan G. Donaldson, Beverley Pitman, Vicky Scott, Heather A. McKay, and Maureen C. Ashe. Concept mapping applied to the intersection between older adults' outdoor walking and the built and social environments *Preventive Medicine* Volume 57, Issue 6, December 2013, PP 785–791.
- 16 Gwo-Jen Hwang, Hui-Chun Chu, and Yi- Rong Liang. Effects of an integrated concept mapping and web-based problem-solving approach on students learning achievement perception and cognitive loads 12th IEEE International Conference on Advanced Learning Technologies 2012.
- 17 Roshanak Mehdipanah, Davide Malmusi, Carles Muntaner, Carme Borrell. An evaluation of an urban renewal program and its effects on neighborhood resident's overall wellbeing using concept mapping *Health & Place* Volume 23 , September 2013, PP 9–17.
- 18 http://en.wikipedia.org/wiki/List_of_concept-_and_mind-mapping_software.