CONCEPT MAP-BASED VS. WEB PAGE-BASED INTERFACES IN SEARCH AND BROWSING

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INTRODUCTION

Searching information quickly and accurately in hypermedia settings is important in educational and research settings. Interfaces that provide structure in a form that is meaningful to the user should make it easier for the user to find information.

Research in our laboratory (Carnot, Dunn, Cañas, Gram & Arguea, 2000) suggests that concept maps (Novak & Gowin, 1984) based on an expert's knowledge model of a domain can provide a useful navigation device for hypermedia. Concept maps depict the concepts and relationships in a domain in a graph that is arranged in a hierarchical way, however, concept maps can depict non-hierarchical relationships through the use of crosslinks (Novak & Gowin, 1984). Using an expert's concept map as a browser may provide an inherent organizational structure that is more useful to the learner for navigating information in a hypermedia environment than more typically used interfaces such as web pages and linked text (Cañas, Ford & Coffey, 1994). When used in this way, the concept maps serve as an advance organizer for multimedia materials (Willerman & MacHarg, 1991).

The concept map interface in the current experiment was constructed using the CMapTools software package developed by the Institute for Human and Machine Cognition (available at http://cmap.coginst.uwf.edu). The patented software allows a designer to build an interrelated set of concept maps, and to attach multimedia resources to concepts. Thus a multimedia learning environment can be created which depicts an expert's knowledge model of a domain, with concept maps organizing and providing access to and resources.

In this research, an interface based on concept maps is compared to more typically used interfaces of web pages and linked text. Web pages are the most typically used interface, and provide access to materials that is primarily serial and page-based. Concept maps differ from other interfaces because they provide a graphical organizational structure of concepts that may enhance access even when the order of search is non-optimal (as in browsing). In the current research, linked text interfaces provide a non-graphical depiction of the relational information in the concept maps.

Previous research has indicated that individual differences in meaningful learning may be related to effective use of concept map interfaces (Carnot, Dunn, Cañas, Gram & Arguea, 2000). Meaningful learners are actively involved in learning, they look for and organize information around main ideas, they relate new information to previous information, and they look for personal meaning in learning (Novak, 1998). Our previous research has used the Learning Approach Questionnaire (LAQ) (Donn, 1990) to determine a person's meaningful learning style. Concept maps have benefits for all users, but are most beneficial for individuals identified as having a meaningful learning style. For this experiment we hypothesized that meaningful learners may be less affected by random order of search questions than rote learners when using the concept map interface.

Thus, the present experiment was designed (1) to compare search performance using the concept map interface with using a web page or a linked text interface, (2) to determine the effects of question order on search performance and (3) to determine the effects of learning style (meaningful vs. rote) on the effective use of the interfaces.

PROCEDURE AND DESIGN

Sixty-two undergraduate psychology students received extra credit for their participation. All completed the LAQ and were assigned to meaningful or rote learning style groups based on a median split of the scores. Participants were then were randomly assigned to interface and search

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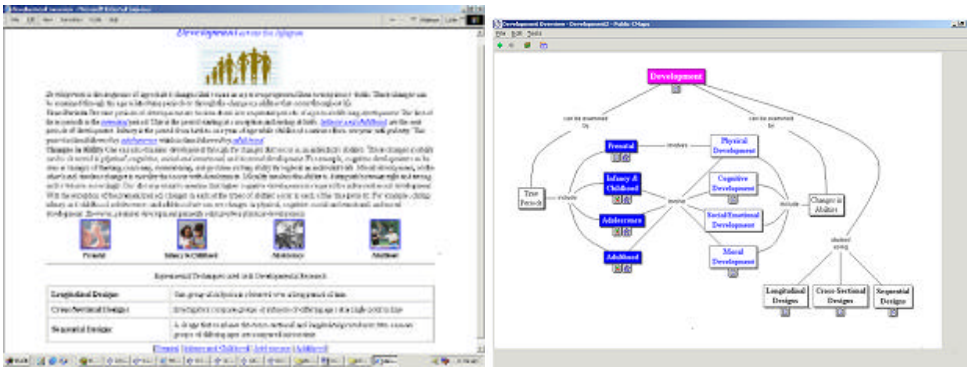
order conditions, and were asked to answer as many search questions in their assigned interface and question order condition as they could in a 50 minute time period. They were asked to answer the questions in order without skipping questions. The primary dependent measure was percent of search questions correctly answered. The independent variables were interface, learning style, search question order, and meaning level (described below), resulting in a 3 (Interface) by 2 (Learning Style) by 2 (Search Question Order) by 3 (Meaning Level) mixed design, with Meaning Level as a within subjects variable. Learning style was not manipulated but determined by score on the LAQ.

The three interfaces (concept map, web page and linked text, shown in Figure 1) were developed based on an introductory chapter concerning developmental psychology. Participants had no prior formal class work on this topic. The interfaces were used to organize supporting resources.

The concept map and linked text interfaces were identical in terms of wording and linking structure. Web pages were as close as possible to the other two in content and structure, but were designed to be more like typical "good" web pages, and appeared more filled in and textbook-like than the linked text interface.

Figure 1: Examples of Top Level Web Page, Concept Map, and Linked Text Interfaces



Development

Development can be examined by time periods. These time periods include the prenatal period, infancy & childhood, adolescence and adulthood. Development can be examined by changes in abilities. These changes in abilities include physical development, cognitive development, social/emotional development, and moral development. The prenatal period primarily involves physical development. The other time periods: infancy & childhood, adolescence and adulthood, involve physical development, cognitive development, social/emotional development, and moral development. Development is studied using longitudinal designs, cross sectional designs, and sequential designs.

Developmental Time Periods:

[Prenatal Period | Infancy & Childhood | Adolescence | Adulthood]

Concept maps and other interfaces were constructed to cover information at different meaning levels – gist or main idea, supporting information, and detail levels. These meaning levels were addressed in the search questions.

Two orders of 75 search questions were developed. Ordered questions followed the logical order in which information was covered in the three interfaces, and is considered an "optimal order." In the random question, or "non-optimal" order, a single random order of questions was developed.

RESULTS AND CONCLUSIONS

The results presented here are based on percent correct of all search questions. Participants were classified into low and high meaningful learners based on Learning Approach Questionnaire (Donn, 1990). A four-way mixed ANOVA was performed on the percent correct data.

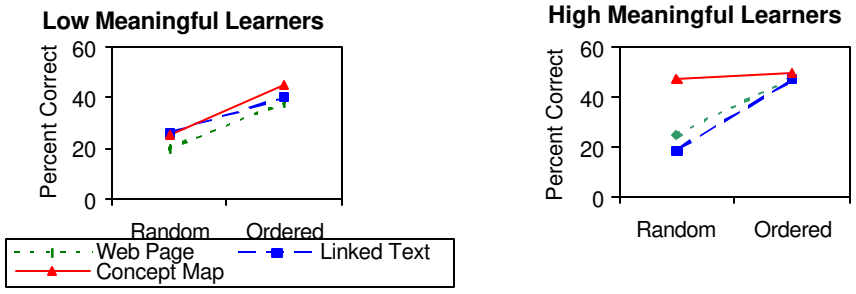
Concept map users (M = 38.98, SD = 13.93) had greater mean search scores [F (2,50) = 6.02, $p < .05$] than web page users (M = 33.48, SD = 18.26) and linked text users (M = 33.07, SD = 15.60). Participants who answered questions in the order of presentation in a given interface (M = 45.62, SD = 12.52) performed better [F (1, 50) = 116.06, $p < .001$] than those who answered them in

random order (M = 24.92, SD = 11.46) and meaningful learners (M = 40.16, SD = 16.91) performed better [F (1,50) = 4.89, p < .05] than rote learners (M = 32.01, SD = 14.05). The effect of meaning level was also significant [F (2,100) = 51.30, = < .001], indicating that gist level questions were answered correctly more often than supporting or detail level questions (Means are 57.30, 27.44, and 39.04 for gist, supporting and detail level questions, respectively).

The two-way interaction between meaning level and question order was significant [F (2,100) = 70.97, p < .001], indicating a greater change across meaning level for ordered questions than for random questions. This interaction is most likely due to the fact that gist level questions were primarily answered first in the ordered question condition.

The three-way interaction (Figure 2) between learning style, interface, and question order was significant [F (2,50) = 3.35, p < .05]. If meaningful learners used the concept map interface, they had superior search performance regardless of search order. Non-meaningful learners' performance was adversely affected by random order questions regardless of interface. In fact, with the other interfaces so was the meaningful learner's search performance.

Figure 2: Percent Correct for Low and High Meaningful Learners as a Function of Interface and Search Question Order



These results indicate that concept maps can successfully be used as organizing structures for knowledge models and multimedia. They may be particularly beneficial when learners can be guided through the material in a logical way (i.e. through LEO, Coffey & Cañas, 2000). If users can be encouraged to be meaningful learners, optimal ordering of materials may not be as critical. Providing an optimal order may also be more important for users with little prior knowledge.

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