# CONCEPT MAPS AND KNOWLEDGE BUILDING DISCOURSE: A USER INTERFACE PROTOTYPES FOR THE NEXT GENERATION LEARNING TOOLS

*Teemu Leinonen[1], Nathan Dwyer[2], Jukka Purma[1]*
*[1]Media Lab, University of Art and Design Helsinki,  [2]SRI International, USA*

**Abstract**. This paper presents an idea of a poster with an interactive installation. The aim of the poster is to open discussion about the possibilities to combine the principles of concept map and knowledge building discourse techniques in a way that will benefit meaningful learning. The poster will include four design proposals and prototypes with the possibility to try out how a combination of concept map tool and knowledge building tool could work. The proposed prototypes are studies of the possible interaction among the participants aiming to achieve meaning on complex topics and gain higher cognitive and intelligence skills needed in a knowledge society.

## 1    Introduction

In a poster presented in this paper we will introduce four user interface prototypes that combine concept map creation and knowledge-building discourse techniques and tools.

The objective is to use concrete user interface prototypes to introduce new ideas about computer tools can support meaningful learning. The user interface prototypes are presented for the concept map research community to evaluate, to discuss and to build on. The prototypes represent explorations of possible new directions in the design of the next generation learning tools.

Even though the thinking behind concept maps and knowledge building come from different traditions of learning theories -- the first building more on individual cognitive learning theories and the second more on cultural psychology -- the approaches should not be considered as irreconcilable. In both approaches the emphasis is on meaning making in the sense of aiming to understand complex concepts and their relations in the world. The main differences between the two approaches are in the way they define knowledge: as an individual structure representing something that is (or not) "the truth", or something that is by nature contextual, culturally and historically embedded and as a such socially distributed and constructed.

## 2    Principles of Concept Maps in Learning

The idea of concept maps is a result of Joseph Novak's (1984) and his colleagues' work based on David Ausubels' (1963) theory of learning. According to Ausubel, making meaning is central to all human learning. Learning with meaning, or meaningful learning, requires the ability to structure ones knowledge and the ability to add new knowledge to existing structures. Concept maps aim to visualize knowledge structures in terms of conceptual elements and the relationship between them. The process of making concept maps is intended to help with conceptualizing and memorizing knowledge.

This way learning with concept map is usually based on the assumption that learning takes place by assimilation of new concepts into existing conceptual network (Novak & Cañas, 2008). This assumption requires a strong analogy between the concept maps as artifacts and the human conceptual network -- a cognitive state. It is, however, an open question if the analogy holds and if there are mental equivalents for processes students can do with concept maps and whether these processes benefit meaningful learning.

Following the cognitive learning theory of Ausubles (1963), Novak and Cañas (2008) distinguish between meaningful learning and rote learning. Novak and Cañas define three preconditions for meaningful learning: (1) The material to be learned is conceptually clear, (2) the material is combined to relevant prior knowledge, and (3) learner has chosen to do meaningful learning.

The CmapTools is the most widely used software tool for creating concept maps. Novak and Cañas (2008) offer a description of learning activities using CmapTools that is intended to produce meaningful learning. They define their approach as a "guided inquiry"-model, where instead of free form study projects the inquiry is based on expert skeleton maps. The expert skeleton maps are simple and sparse concept maps created by an expert of the subject field and they are intended to provide scaffolds for learners' concept maps. This is justified by noticing that as concept maps grow, false information and misunderstandings are often difficult to notice and correct, so it is better to have everyone begin building on a solid base. The building of concept maps should also

be guided by a focus question, which sets the direction and limits of inquiry. Adding new concepts to expert skeleton maps can be done individually or from "knowledge soup", where learners add concepts to common pool, but concepts' links to other concepts are kept private. This allows keeping concept maps individual but comparable. Concept maps can also be edited and commented collaboratively.

A good concept map according to Novak and Cañas (2008) should consist of concepts with simple labels, but with exact relations between them. A concept node can contain links to other resources and a possible clarifying text. If the concept is itself a complex concept, which would benefit from a concept map to explain itself, this is implemented by cross-linking the concept to other map or subsection of a map. In a good concept map reorganizing and modifying the map is easier, as relationships and concepts are clearly separated: relationships between the concepts can be redefined without changing the concept itself. It is not, however, clear that human conceptual system has this kind of separation. With concept maps the common difficulty of learning to use "linking words" properly may be related to the nature of human semantic system.

Theories of human semantic systems (Jackendoff 2003, Pustejovsky 1995, Fodor 2002, Chomsky 2002) suggest that concepts in a human mind are anything but clearly defined. It is common for concepts to have at least several aspects that are invoked depending on what kind of action concept is participating: for example a bank is an abstract institution and a building, and the concept of money is even more complicated. Similarly meanings of predicates are similarly context dependant: run, run for a president, run there, a good run is an example of how the meaning of concepts is made only in the context they are used. These kinds of difficulties do not usually rise when working with small concept maps, especially when the focus question helps to direct attention toward one aspect of ambiguous concept. Also many things that are easy and natural to create with language are difficult to express with concept maps: adjectives when there is a need for different outcomes for same adjective: difficult birth and difficult test would require two separate instances of concept difficult, or the implications of difficult birth and difficult test would become mixed.

## 3    Principles of Knowledge Building Discourse in Learning

In the same way that Novak and Cañas (2008) base the idea of concept maps on an attempt to reach meaningful learning, so do Scardamalia and Bereiter with their idea of knowledge building (2003). Knowledge building changes the focus of "learning" from merely a process that results in change of individual belief, attitude and skills to something deeper, often called meta-cognitive. The most fundamental results of knowledge building are critical thinking skills, with advantaged methodological and epistemological understanding. Knowledge building practices are claimed to guide people to "developmental trajectory leading from the natural inquisitiveness of the young child to the disciplined creativity of the mature knowledge producer" (Scardamalia, M., & Bereiter, C. 2003).

Scardamalia (2002) has defined the principles of knowledge building communities. First of all participants in a knowledge building community should focus on authentic problems and real ideas in a real world. All the ideas presented by the participants should be regarded as ideas that can be improved. The diversity of ideas and point of views are seen necessary to improve the ideas. From the variety of ideas, the participants should be able to "rise above" individual ideas and create new concepts that are higher level concepts than the original concepts and ideas presented by the participants. The participants should hold epistemic agency - their should negotiate a fit between their personal ideas and ideas of others and this way sustain knowledge advancements. The ownership of the knowledge should be shared and all the participants should have a same rights to contribute to the collective community knowledge. Participants should use variety of information sources and have a respect and understanding of authoritative knowledge sources combined with a critical stance towards them. The knowledge building discourse should be more than just sharing of knowledge - the overall explicit goal of the participants should be advancement of knowledge. Evaluation and assessment of the activity is considered as part of the effort to advantage knowledge. This way the participants should engage in its own internal assessment, that is pervasive and ongoing. A kind of side or meta products of knowledge building focusing on to advantage knowledge on some specific topic are often considered to be critical thinking, increases in literacy, information search and general productivity in knowledge intensive work.

The Fle3 Knowledge building tool (KB-tool) is a software component designed to support and enhance knowledge building discourse. The KB-tool is part of the Fle3 (http://fle3.uiah.fi), server software for computer supported collaborative learning (CSCL). Fle3 is designed for group-centered work that concentrates on creating and developing expressions of knowledge. KB-tool is group tool for having knowledge building discourse, theory building and debates in a shared database. KB-tool includes Knowledge Types to scaffold and

structure the process. With the KB-tool the participants can post notes to the share database and when posting the participants are asked to use knowledge types summarizing the main thinking mode presented in the note. When selecting the knowledge type the KB-tool offers guidelines and checklists on how to write notes to the database. For instance, the Progressive Inquiry knowledge type set contains the following knowledge types: Problem; My Explanation, Scientific Explanation, Evaluation of the Process and Summary

The knowledge types guide students to think about the knowledge creation process, and helps students to write more substantial notes to the database. As an aid for users to follow the knowledge building discourse, users may take different views to the knowledge building database by sorting the notes as a discussion thread, by writer, by knowledge type, by date or on freely editable spatial map view. An advanced search engine allows searching the database of notes by title, author, course context or words used in the note. KB-tools are designed for progressive discussion, thinking, and pondering in a group as well as act as the collective memory of the process. These features of the tools are intended to help participants to identify the key centers of the collaborative activity, who is involved in the key centres of activity, who is working with whom, what new ideas are currently receiving the most attention, how one can participate in advancing the work of the collective etc. These are critical capabilities of knowledge building tools that move them beyond traditional threaded online discussions.

## 4    Four User Interface Prototypes

Combing concept maps and knowledge building discourse can be carried out by bringing concept maps to knowledge building or by bringing knowledge building to concept map creation. In the following we will describe four different prototypes where concept maps are integrated into knowledge building discourse.

### 4.1    Concept map as a media type in all knowledge building notes

With the current KB-Tool, participants may add in-line images to the knowledge building notes and links to external resources. The reasons to limit the use of media to images, and not having audio or video in the notes, are pedagogical. The process of writing notes and presenting arguments in a written form is considered to advantage the common knowledge in more easily reusable form than in a case of using time-depending media. Also formatting written notes is seen to advantage participants' thinking and argumentation skills. The concept maps inside knowledge building notes should be simple images used to explain or illustrate arguments. The concept map should be static images so that one could not change the content anymore when the note was posted to the database. One possibility is, however, that the concept map image is always just one revision of the map and one can build on it and use a new version in some other knowledge building note.

### 4.2    Concept map as a media type in notes that are some specific type

We may consider some pedagogical reasons to limit the use of concept maps only to some type of knowledge building notes. For instance, the concept map can be considered to be a tool to present a summary of the knowledge building discourse or as a rise above note bringing the knowledge building discourse on a new level. In one shared concept map the participants could bring together and summaries their discourses taking place in different places. The concept map could be collaboratively own by all the participants and the common map could be used as the context for a new knowledge building discourse. Based on the concept map the participants should formulate their new study problems for further discourse.

### 4.3    Knowledge building discourse notes inside concepts

Each concept is a concept map could also act as a discourse note, with more content and argumentation under each concept. This way the actual concept would be the subject of the note. The concepts / subjects of notes would be linked to each other in a normal concept map creation style, but inside each concept there could be more explanation and argumentation related to the content of the concepts. The concepts should not be editable, but one could start at any point a new creation of concept map / discourse that is building on some earlier concept map / knowledge building discourse. The difference to the current CMapTools feature of having a description of the concept is the aim to support discourse with the notes. This way the note attached to the concept should not be a description "hide" to inside the node, but the main content aiming to explain it and build on other notes presented in the map.

*4.4   Knowledge building discourse and concept maps side by side*

When writing a knowledge building note the participants could be asked to add also a single most important concept, keyword of tag related to the discourse note and relate it to other concepts presented in the discourse. This way the collective concept map would live next to the knowledge building discourse but in a close relation to the discourse. Based on the concepts, keywords or tags the system could also cluster notes that share the same concept, keyword and tags and could this way offer another alternative view to follow and keep eye on the discourse.

**References**

Ausubel, D. (1968). Educational Psychology: A Cognitive View. Holt, Rinehart & Winston, (New York), 1968.

Chomsky, N. (2002): On Nature and Language. Cambridge University Press.

Fodor, J. A.; Lepore, E (2002): The Compositionality Papers. Oxford University Press.

Jackendoff, R. (2003). Foundations of Language, Brain, Meaning, Grammar, Evolution. Oxford University Press 2003.

Novak, J. D., & Gowin, D. B. (1984). Learning How to Learn. New York: Cambridge University Press.

Novak, J. D. and Cañas, A. J. (2008) The Theory Underlying Concept Maps and How to Construct and Use Them, Technical Report IHMC CmapTools 2006-01 Rev 01-2008, Florida Institute for Human and Machine Cognition, 2008.
http://cmap.ihmc.us/Publications/ResearchPapers/TheoryUnderlyingConceptMaps.pdf

Pustejovsky, J. (1995): The Generative Lexicon. MIT Press: Cambridge, MA.

Scardamalia, M. (2002). Collective cognitive responsibility for the advancement of knowledge. In B. Smith (Ed.), Liberal education in a knowledge society (pp. 67-98). Chicago: Open Court.
http://ikit.org/fulltext/2002CollectiveCog.pdf

Scardamalia, M., & Bereiter, C. (2003). Knowledge Building. In J. W. Guthrie (Ed.), Encyclopedia of Education, Second Edition (pp.). New York: Macmillan Reference, USA. Retrieved from http://ikit.org/fulltext/2003_knowledge_building.pdf