

Knowledge Building in Distributed Collaborative Learning: Organizing Information in Multiple Worlds

Anders Mørch
InterMedia
University of Oslo
Norway
+47 22840713

anders.morch@intermedia.uio.no

Karianne Omdahl
Department of Information Science
University of Bergen
Norway
+47 55558381

karianne.omdahl@uib.no

Sten Ludvigsen
InterMedia
University of Oslo
Norway
+47 22840712

sten.ludvigsen@intermedia.uio.no

ABSTRACT

In the CSCL (Computer Supported Collaborative Learning) community a recent topic of keen debate has been whether or not online discussion forums should be typed or not (i.e. information categorized according to predefined message types). We have analyzed findings from a field trial with Future Learning Environment (FLE) and we identified some problems with the system's knowledge building categories. We propose to integrate collaborative knowledge building with physical modeling (designing with materials) to get more mileage out of information categorization. This is stimulated by Donald Schön's bottom-up approach to information categorization, from design materials to repertoires of cases.

1. Design according to Schön

In a series of empirical studies of professionals in a range of domains Schön (1983) has shown that information categorization to a large extent is bottom up work rather than originating from readymade categories. This process starts from "materials of a situation" and in a good process of design results in new understanding realized as a "case" added to an existing repertoire of cases. The notion of a *repertoire* is more fluid than a concept and constructed out of the local, often messy, situation a person finds himself in when solving a design problem, but in the end is linked with existing understanding so that it can be reused in future situations requiring similar problem solving. A repertoire is thus distinguished from a category set by being the result of a combination of bottom up (situation specific) sense making and top-down structuring of existing understanding. In his own words, analyzing an architect at work, Schön describes the design process as follows:

"When a practitioner makes sense of a situation he perceives to be unique, he sees it as something already present in his repertoire. To see this site as that one is not to subsume the first under a familiar category or rule. It is, rather, to see the unfamiliar, unique situation as both similar to and different from the familiar one, without at first being able to say similar or different with respect to what. The familiar situation functions as a precedent, or a metaphor (Schön 1983, p. 138).

The quote suggests categories (as flexible repertoire) should be allowed to evolve over time, stimulated and informed by a reciprocal relation of adaptation and situational "back talk". Adaptation occurs when categories are used locally and the back talk provides feedback to regulate the adaptation process so that it makes sense to the participants.

Even though students are not professionals in the sense just described they need to take part in similar processes to successfully learn. For example learners need to engage in a process of grounding, i.e. interaction necessary to establish a common ground to complete collaboration tasks (Baker et al., 1999, Koschmann & LeBaron, 2003). Physical modeling by manipulating domain-specific materials is one form of grounding appropriate for conceptual knowledge building. The following quote by Donald Schön is illuminating in this regard:

"the designer's moves tend, happily or unhappily, to produce consequences other than those intended. When this happens, the designer may take account of the unintended changes he has made in the situation by forming new appreciations and understanding and by making new moves (Schön, 1983, p. 79)."

Design according to this occurs on two levels. On the one hand, it is about "forming new appreciations and understanding," on the other it is about "making moves" in the domain. Moves with unintended consequences can serve as triggers for conceptual knowledge building by identifying new problems (framing of issues) that may require exploration and explanation before new moves can be made.

2. Conceptual Knowledge Building

CSCL focuses on technology in its role as mediator of activity within a collaborative setting of instruction and learning, learners and facilitators. It has inherited its intellectual legacy from theoretical schools in the social sciences, in particular sociology, anthropology, and communication (Stahl, 2002). Knowledge, from this perspective, is seen as a human construction elaborated through communication and collaboration with peers, mediated by social and cultural artifacts implying that learning and knowledge building first of all occur on inter-personal grounds within a community of learners before occurring on the intra-personal realm of the individual learner (Vygotsky, 1978).

A pedagogical model developed within this perspective is *Knowledge Building* (Scardemalia & Bereiter, 1994). Knowledge building entails that new knowledge is not simply assimilated with the help of a more knowledgeable person, but also jointly constructed through solving problems with peers by a process of building mutual understanding in some domain of inquiry. Knowledge building and its subsequent refinement *Progressive Inquiry* (Hakkarainen, Lipponen, & Järvelä 2002) have received considerable attention in the CSCL community. A reason for this is that the model fits well with the educational philosophy

instituted by many schools in Canada and Scandinavia (problem-based learning), as well as elsewhere in the world. The basic idea is that students gain a deeper understanding of a knowledge domain by engaging in a research-like process in this domain by generating their own problems, proposing tentative hypotheses and searching for deepening knowledge collaboratively with peers.

FLE (Future Learning Environment) is an open-source learning environment (<http://fle3.uiah.fi/>) developed according to the Progressive inquiry model. It is an asynchronous web-based groupware for computer supported collaborative learning (Muukkonen, et al., 1999). It is designed to support collaboration in the form of a discussion forum with message categories (information types) named after the stages of the progressive inquiry model.

Students using FLE are required to choose a knowledge-building category each time they post a message to other students. Although the initial questions were articulate and easily entered into FLE, responding to them by selecting a new information type was more difficult. In an empirical study (Ludvigsen & Mørch, 2003; Mørch, Dolonen & Omdahl, 2003) we identified recurring problems with using the FLE categories (content/category mismatches). We also identified student strategies of resolving them, such as trial and error: referencing a subset (or the whole range) of the categories to see if any one of them could apply. This strategy of information categorization is partly supported by the system. However, the teacher would also on occasion tell the students what each of the categories meant.

3. A Proposal for Integrated Knowledge-Building Environments

When the categories of a groupware are inappropriate to a situation at hand it may be because the situation is unique. Rather than forcing a "best match" on top of the situation the category be expandable and adaptable to the situation. This may have the dual effect of engaging those with skills to create new categories as well those with difficulties using the existing category set.

Although information categorization can be remedied by making categorization structures more transparent (e.g. with the use of everyday terms) we do not want to water out categorization structure entirely, since semi-structured messages can be surprisingly useful as basis for computer support (Malone et al., 1987). Instead, we propose a combination of user-tailorable categories and domain-specific designer kits with computational design materials serving as electronic lenses transforming and connecting the local situation with the conceptual information space.

Many knowledge domains consist of domain-specific rules and building blocks that adhere to general principles that define broad conceptual spaces within which small-scale experiments can mark individual trajectories (e.g. mathematics, physics, biomedical engineering). These design elements or "domain distinctions" (Fischer et al., 1995) are not exploited in the current generation of knowledge building environments. On the contrary, the term knowledge building has become synonymous with manipulation of *conceptual artifacts* (Bereiter, 2002). Although the computer is well equipped to support conceptual artifacts as we have shown above, it is even better equipped to support modeling and

simulation of physical phenomena, which we have tentatively dubbed "physical knowledge building" to complement conceptual knowledge building.

Modeling and simulation of physical phenomena is not foreign to designers of collaborative learning environments and has been acknowledged as being important for stimulating learning activity in many knowledge domains (e.g. Papert, 1991; Fischer et al., 1995; Roschelle et al., 1999). However, this approach has received little attention in the knowledge building community and few attempts have been made at building bridges across the two worlds from the other side. We start by making a first move and suggest that the following hypotheses should be implemented and empirically tested in the next generation of knowledge building environments:

- Integrated knowledge building environments are needed for full support of distributed collaborative learning
- Integrated knowledge building environments need computer support for conceptual and physical knowledge building within the same computational environment
- Physical knowledge building can be supported by domain specific designer kits
- Designer kits need to align with the established domain distinctions of a particular knowledge domain
- Designer kits will make it easier for physically active students to engage in knowledge building
- Designer kits can complement existing (conceptual) knowledge building environments and help to focus collaboration activity
- End-user tailorability and intelligent agents are two computational techniques that can help to link general information categories with domain-specific, situations of a designer kit
- Automatic (adaptive) classification by the computer suggesting categories on the basis of analysis of the current situation in the learning environment

4. Related Work

The following past (and contemporary) work and system building describe related initiatives, directly and indirectly.

Grace (Atwood et al, 1991) was an integrated learning environment for Cobol programming. The Grace environment consisted of a suite of tools for different aspects of programming. For example, the environment included an intelligent tutoring component, a Cobol construction kit, and a Cobol critic. The system was field-tested in the training center at corporate headquarter of a regional telephone company (NYNEX). It was also a single user environment and implemented on the Symbolics machine.

VKB (Virtual Knowledge Builder) (Shipman, et al., 2002) is a distributed, spatial hypertext system allowing multiple users at different sites to manipulate shared ideas. The system is domain-independent, and implemented to allow collective creation, editing and manipulating of free-form textual notes. VKB has a

set of suggestion agents that can recognize certain semantic attributes and values of the notes and suggest various ways to classify and reorganize them. For example a type suggestion agent can analyze the attributes and visual properties of a newly create (untyped) note and suggest a classification for it based on matching it with the existing set of typed (categorized) notes, and by doing so helping the users with grouping ideas into meaningful clusters.

Epsilon (Soller, 2001) is an intelligent facilitation agent that is integrated with a shared graphical editor for the domain of object-oriented analyses and design using OML (Object Modeling Language). Collaboration among students is scaffolded by everyday sentence-openers (such as "Do you know", "Please show me", "Let me explain it this way", "To justify", "To summarize", etc) modeled after speech act theory, but in a more user friendly way. Epsilon can observe a group's conversation and dynamically analyze individual contributions. For example, it can recognize events such as a student having failed to discuss his or her work with others. When it detects an opportunity to react, the agent might intervene by asking the group to explain the student's actions. If the students in return are not able to select the proper sentence openers for this type of utterance the agent might intervene and tell them about the role of explanation in group learning. Epsilon continues the top-down tradition of information categorization, but the categories are now easier to select because they are mixed with everyday terms.

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