Evaluating Distributed Computer-Supported Cooperative Learning (D-CSCL): A Framework and Some Data

Hans-Rüdiger Pfister, Martin Wessner, Torsten Holmer, Ralf Steinmetz
GMD-Forschungszentrum Informationstechnik GmbH (IPSI), Dolivostr. 15, 64293 Darmstadt, Germany {pfister, wessner, holmer, Ralf.Steinmetz}@gmd.de

D-CSCL (for Distributed Computer Supported Cooperative Learning), refers to approaches that aim at improving learning processes of groups of learners which are geographically distributed and connected by computer networks. The success of such learning technologies critically depends on sound evaluation, formative as well as summative. We first describe a general evaluation framework for D-CSCL systems. We then introduce VITAL, a cooperative learning environment prototype for distributed groups. We report preliminary evaluation results of the VITAL system. Though results show that acceptance and usability is satisfactory, issues such as group-awareness and action coordination remain problematic. We close with an integrative architecture for D-CSCL systems.

KEYWORDS: COMPUTER SUPPORTED COOPERATIVE LEARNING (CSCL), DISTRIBUTED LEARNING, EVALUATION

INTRODUCTION

The evaluation of D-CSCL systems (for Distributed Computer-Supported Cooperative Learning; see also [1] for an overview on CSCL systems) is one of the more difficult areas of software evaluation. Some reasons for this situation are: (a) only few systems currently exist which are worthwhile to evaluate, or which have been evaluated; hence overall experience is small; (b) in addition to purely technical aspects, usability and usefulness of D-CSCL systems is much more complex than in other systems, due to the multiplicity of users and due to their distribution across space and time; (c) any learning system is applied within a highly specific organizational and didactical context, as well as based upon a very specific technical environment (which are both constantly changing); this context-dependency makes it difficult to evaluate a learning system per se.

Hence, we need to take a wider perspective on evaluation. In the next section, we propose a general evaluation framework for distributed cooperative learning environments. This is especially important if we deal with generic learning environments, which are domain
independent, and which are developed to support groups of learners for a wide variety of learning problems. A system that falls into this category of learning environments is VITAL, a prototype developed at our institute. We shortly describe its main features and intended applications. In the third section, we report some preliminary data collected to evaluate the VITAL system. These results highlight major problems of D-CSCL systems: how to provide group-awareness, and how to support structured cooperation.

AN EVALUATION FRAMEWORK

In contrast to traditional ways of computer-supported learning, e.g., a single individual using a PC to navigate through a CD-based multimedia course, distributed cooperative learning includes a number of complexities for evaluation. First, it is not at all clear what exactly constitutes the unit of evaluation. Is it the concept of distributed cooperative learning as a general didactical approach, or is it a more specific cooperative method, or is it a specific D-CSCL implementation? We think that - considering the current state of research on cooperative learning methodology and on available technologies – we need to proceed bottom up: i.e., to look at a specific system in a specific context and check how it works. Then we might be able to generalize to other similar systems or to aspects of the methodology as such.

Furthermore, in order to evaluate a piece of software, we need to define the typical user using the software. With a single user CBT-system, it is simply the single individual taking the course that serves as the subject of the evaluation procedure. With a cooperative system, however, one needs to decide if it is a (e.g., randomly picked) individual from the cooperating group, or if it is each member of the group (evaluated on a case-by-case basis), or if it is the group as a whole. Speaking of cooperation proper, we argue that the appropriate unit of evaluation should be the cooperating group, which is in a sense different from the sum of individuals. For example, consider a working team consisting of two “experts” and three “novices”, the experts teaching and the novices learning a specific task that arose during their daily work. Support should be given to the entire process of knowledge transfer and acquisition, i.e., the experts should be able to easily express their knowledge and the novices should be able to easily acquire new knowledge, and to exchange problems and questions. Looking at only one participant is not sufficient to know how the system works as a whole. This implies that one should not just evaluate if one individual did learn efficiently during the cooperative process, but to evaluate the interaction among learners, among learners and experts, and among learners and tutors.

Secondly, one should be precise about the goal of the evaluation process, i.e., which evaluation question one wants to answer, e.g.: Should system X be used in school? Is system X better than system Y? Which aspects of system X need improvement, which aspects and functions are missing, and which aspects should be emphasized? We propose to focus on the latter questions, which implies that formative evaluation is more important than summative evaluation [2]. Considering the amount of resources going into the development of D-CSCL systems, and considering how little established knowledge we have in this area, continuous formative evaluation is indispensable for successful development.

This leads to a third complexity: Since little experience is available, we even are unclear about the proper criteria to employ for evaluation, i.e., we are unable to formulate from the very beginning the set of criteria upon which the evaluation decision will eventually be based. But precise evaluation criteria are the conditio sine qua non for sound evaluation. Hence, we
argue that formative evaluation of D-CSCL systems needs to proceed along two intertwined levels: on the level of system development, the evolving systems needs to be judged and adjusted according to the current set of criteria. But at the same time, on the level of evaluation criteria, the criteria themselves need to be changed and adapted according to new findings and new constraints that result from system development. We conceive of formative evaluation not only as the process of continuous system evaluation and redesign, but additionally as the continuous evaluation and reformulation of the evaluation criteria themselves. For example, originally the criteria “videoconferencing” might come up as an important criteria. However, if it turns out that videoconferencing is not important for learning processes (compared to audio communication) in a given context, instead of evaluating a system as “low” on the video-criteria, one might give it up altogether and readjust the importance of the audio-criteria.

Fourth, the formative evaluation needs to be performed on four levels simultaneously:

- The pedagogical-psychological level
- The technical-functional level
- The organizational-economical level
- The socio-cultural level

The pedagogical-psychological level includes all criteria referring to the learning process itself. For example, criteria such as support of different didactic methodologies, how to represent and modify knowledge, tools to define learning goals, or support for different roles (learners, trainers, tutors) need to be assessed on this level. The technical-functional level includes criteria that refer to the proper functioning of a concrete system, i.e., criteria such as stability, required bandwidth, interface design, etc.; what counts as satisfactory on these technical criteria is normally subject to rapid change. The organizational-economical level deals with aspects of organizational context and constraints, e.g.: how does D-CSCL based learning fit with other forms of training in the organization? How efficient and cost-effective are computer-supported learning processes compared to traditional ways of training? And finally, the socio-cultural level evaluates how a system fits into the overall (learning) culture of the organization, and how it is accepted by its users from a cognitive, motivational, and emotional point of view.

**VITAL – A COOPERATIVE LEARNING ENVIRONMENT**

As a concrete example of a D-CSCL system, we briefly sketch the VITAL prototype, recently developed at GMD-IPSI. VITAL (for Virtual Teaching And Learning) is a member of a family of groupware systems: DOLPHIN [3], which focuses on meeting support; SEPIA, developed for cooperative authoring [4]; CHIPS [5] and SCOPE [6] for collaborative work. VITAL aims at supporting small and medium sized teams of adult learners. Its main objective is to enable users to learn about a large range of topics (i.e., VITAL is domain-independent) by providing a virtual environment and a set of tools that are intuitive to use and conducive to coordinate communication and cooperation processes typical for learning.

In VITAL, all users work with cooperative hypermedia documents. They can view documents and create new ones, with arbitrary complexity by introducing new links. Users live in so-called virtual rooms, which make up the learning world. Virtual rooms provide a metaphor that serves the purpose to support orientation and group-awareness in the learning environment [7]. Users that occupy the same room have the same view on the presented
material, they are aware of each other, can communicate with each other, and they are able to cooperatively manipulate documents. Virtual rooms are especially useful to provide smooth transitions between synchronous and asynchronous modes of learning, since persons in the same room have full group-awareness for synchronous work, but objects (texts, pictures, etc.) remain persistent in a room for later asynchronous work. Figure 1 shows some major components and functions of VITAL.

As can be seen in Figure 1, most of a virtual room consists of a shared whiteboard, where users can cooperatively view and create hypermedia documents. Group-awareness is supported by showing images of all persons currently in a room, and by using personalized telepointers. Synchronous communication is performed via a chat-tool, or by an audio connection; asynchronous communication is performed either by sending emails or by leaving text-messages on the shared whiteboard.

PRELIMINARY EVALUATION

The evaluation was concerned with synchronous presentation and cooperation in different types of virtual rooms. VITAL provides three types of rooms: (i) private homes for individual study, (ii) group rooms for discussion and self-organized cooperative learning, (iii) auditoriums for presentation and teacher-guided learning. In an auditorium, two roles are distinguished, that of a learner and that of a trainer. The trainer controls the learners' access to the material presented as well as to the cooperation tools.

Procedure

VITAL was evaluated in a typical seminar setting at the Darmstadt University of Technology, as part of a computer science course on distributed systems. Six students and one lecturer participated in a two hour session. The students were computer science students, but had no
special experience with groupware and computer-supported learning systems. The technical setup was as follows: Three students (the distributed group) were located in separate locations (rooms) with a PC running the VITAL system. Three students were located in a meeting room (the co-located group), each with a computer running the VITAL system; they were able to see and talk to each other face-to-face. The teacher was separately located in another room at a PC running VITAL (Figure 2). Audio communication was set up via a multi-point telephone conference, using the hands-free mode of the phone.

One week before the evaluation session, the participants obtained a one hour introduction into VITAL. The evaluation session started with a presentation phase, delivered by the teacher with prepared slides in a virtual auditorium of VITAL; this presentation took about 15 minutes. It was followed by a 10 minutes phase of cooperative brainstorming, i.e., all six students generated concepts and ideas about the topic “distributed architectures”. Then, the students split up into two groups of three members each, one group consisted of the three distributed students, the other group consisted of the three co-located students. Each group moved to a separate virtual group room and discussed and structured the material generated during the brainstorming phase. After 15 minutes, the two groups joined back in the virtual auditorium, and the session was finished by a 10 minutes presentation and discussion of the results produced by each group (under supervision of the teacher). Right after the session, a questionnaire was administered, with questions on various aspects of the system.

During the whole evaluation session, each participant was observed by a “silent observer”, who sat behind the participant and took notes on his actions, without interfering with the learning process. The observer notes were roughly classified into usability problems (navigation, editing, etc.), communication problems (chat, audio), cooperation problems (coordination, manipulation of objects, group-awareness, etc.), and technical hardware problems. The questionnaire consisted of sets of items referring to general acceptance (e.g., “all in all, I think VITAL is...useful – not useful”), presentation by the teacher (e.g., “with VITAL, I could more actively participate... yes – no”), group cooperation (e.g., “compared to traditional group learning, VITAL... facilitates cooperation – makes cooperation more learnability of VITAL (“learning to move to different rooms in VITAL is... easy – difficult”). In sum, the questionnaire consisted of about 40 items, which had to be answered on five-point bipolar rating scales, anchored with verbal labels such as “easy “ vs.
We first describe the questionnaire results; some anecdotal evidence from the observers’ notes will be included in the discussion section. Due to the small sample size, all quantitative results should be taken as purely descriptive information (no statistical test were performed); results are summarized in Table 1.

General acceptance was rated as fairly high, i.e., positivity, satisfaction, and usefulness were all rated above four (on a five-point scale). A direct comparison with previous seminar sessions (without VITAL) also yielded a satisfactory result, with a mean of 3.6 (on a five-point scale).

<table>
<thead>
<tr>
<th>Item</th>
<th>Scale (1 ... 5)</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>All in all, I think VITAL is useful</td>
<td>useless ... useful</td>
<td>4.1</td>
</tr>
<tr>
<td>Compared to previous seminar sessions, I like the VITAL session</td>
<td>worse ... better</td>
<td>3.6</td>
</tr>
<tr>
<td>I enjoyed the presentation of material with VITAL</td>
<td>no ... very much</td>
<td>3.3</td>
</tr>
<tr>
<td>I had the feeling to participate more active with VITAL</td>
<td>no ... yes</td>
<td>2.6</td>
</tr>
<tr>
<td>Asking questions was facilitated with VITAL</td>
<td>no ... yes</td>
<td>2.6</td>
</tr>
<tr>
<td>I enjoyed group work with VITAL</td>
<td>no ... a lot</td>
<td>4.5</td>
</tr>
<tr>
<td>VITAL facilitates cooperation</td>
<td>no ... yes</td>
<td>3.8</td>
</tr>
<tr>
<td>With VITAL it is .... to contribute to discussions</td>
<td>harder ... easier</td>
<td>2.8</td>
</tr>
<tr>
<td>I found it ... to move between different virtual rooms</td>
<td>hard ... easy</td>
<td>3.6</td>
</tr>
<tr>
<td>I think I understood the important functions of VITAL</td>
<td>not at all ... definitely</td>
<td>4.5</td>
</tr>
</tbody>
</table>

Table 1: Selected questionnaire results

With respect to the presentation phase, results are more mixed. Though students generally enjoyed the presentation, and understandability of content was satisfactory, active participation and the motivation to ask questions was not substantially facilitated (mean = 2.6). The hypermedia structure with links, however, was rated as highly advantageous; students also assumed that an additional video connection would have been useful. Students enjoyed the cooperation with VITAL a lot (mean = 4.5), and also judged that group learning was facilitated, and that contributions of participants are quite well related to each other. However, students felt that VITAL does not really support students to contribute actively during a discussion, compared to face-to-face settings. The availability of features such as a personalized telepointer, or an annotation function, was rated as very useful. However, none of the students actively created a new hypertext link during the group sessions. Finally, participants thought it fairly easy to learn the main functions of VITAL (see Table 1), with the exception of moving between different virtual rooms.

**DISCUSSION**

A summary of the most frequent observations from the observers’ notes provides further information on the advantages and disadvantages of the VITAL system; we implicitly include these observations while summarizing the main results. Generally, distributed communication and presentation was no problem for this group of participants. Also, no major technical and organizational breakdowns occurred during the evaluation session. Though some students claimed that an additional video conferencing facility would have been useful, observations did not yield any indication that this was actually missed. Overall, the learning goal of the seminar session was achieved very well in this distributed cooperative setting.
We focus now on some more specific issues. First, the metaphor of virtual rooms was not immediately understood. Students had problems to orient and navigate between different rooms; navigation in hypermedia documents on the one hand (i.e., following links) and moving from room to room via the room browser on the other hand, was often confused. The double-structuring into virtual rooms, additional to the hypermedia structure, seems not to be a concept that is immediately grasped. However, once understood, it proved to be fairly intuitive and helpful to establish multiple groups that could work independently in different virtual rooms.

Group-awareness is still a difficult issue. The personalized telepointer (a pointer with an image of the user, see Figure 1) proved to be very helpful. The teacher as well as some students also used it to highlight text objects in order to focus the group attention on this object. However, editing tools are not personalized, i.e., it is not immediately possible to identify who is the author of a text that appears on the shared whiteboard. Especially during the brainstorming stage, as well as during the following group discussion phase, when several participants simultaneously generated text objects, students were sometimes slightly confused. Participants could not easily map audio information (i.e., a person speaking about a text object) onto textual information (i.e., the referenced text object). As a spontaneous means to solve this problem of action coordination, participants used to wave or waggle with the text object in order to draw the group’s attention onto that object.

These problems of group-awareness and action coordination were substantially less severe when the groups were small (i.e., three members) during the group discussion phase. There seems to be a sharp increase in coordination difficulty when group size increases from three to six or seven persons.

To overcome these problems our goal is to extend the VITAL system towards a more comprehensive environment [8]. Figure 3 depicts a schema of this integrated architecture we are currently working on. It includes four major components, the first two have been implemented in VITAL.

First, learners work with cooperative hypermedia documents. Secondly, users live in virtual rooms. Third, rooms provide specific learning protocols, which provide support for structured communication and systematic learning processes. For example, a learning protocol for dyadic explanation supports and guides the alternate process of delivering an explanation (by
the explainer) and of receiving an explanation (by the learner); the entire explanation can be saved and used for later instruction [9]. Fourth, so-called learning nets provide a means to structure the information to be learned on a meta-level. Key concepts are created and connected by typed links, generating a net of knowledge that summarizes the to-be-learned information contained in the hypermedia documents. Preliminary versions of learning protocols and learning nets are currently under development and evaluation.

REFERENCES


Acknowledgements
We would like to thank our colleagues at GMD-IPSI who implemented the VITAL system and helped evaluating it. Many thanks also go to the students who volunteered to act as “guinea-pigs”.