COMMENTARY

Developing Models for Distributed Problem-Based Learning: Theoretical and Methodological Reflection

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Introduction

The traditional strategy in higher education, of setting the internal theory structures of the discipline as the base of the curriculum, and relying on well-defined and segmented study exercises, has not managed to develop students’ abilities to apply their knowledge in complex, ill-defined practical situations (Actenhagen, 1994). This type of higher education often fails to provide students with knowledge and skills applicable to the different problem-solving and activity situations of working life (Mandl et al., 1994). This has led to a strong emphasis of learning experiences in practical situations that are embedded in cultural contexts, or communities of practice. Although this approach has led to important advancement in the planning of learning environments (Bransford et al., 1999), it has also often neglected the importance of learning formal knowledge (e.g., Boshuizen et al., 1995), and the construction of abstract ideas (Ohlsson & Lehtinen, 1997).

The problems of higher education cannot simply be solved by cutting away studies of formal, theoretical knowledge from the curriculum, and by replacing them with direct studies of informal knowledge related to the domain in question.

Although experienced experts have developed rich informal knowledge structures, which give them quick practical reasoning in complex and often ill-defined problem situations, the experts also have a more profound understanding of the formal knowledge of their field than do the novices. Well-structured formal knowledge remains available for use if the informal knowledge, based on practical experience, fails to produce an adequate representation and solution to the problem at hand. Boshuizen et al. (1995) have described high-level experts’ knowledge structures in which the formal knowledge is embedded in informal activity scripts as encapsulated units.

This would mean that formal and informal knowledge should not be viewed as alternative approaches, but the development of high-quality expertise seems to demand them both. Formal knowledge also provides the abstract tools that enable both experts and students to monitor the development of a certain field of knowledge and to gather new information. (e.g., Bereiter &
Knowledge structures based solely on informal and “tacit” knowledge can be very inflexible and provide only limited opportunities for continuous knowledge advancement, typical for dynamic expertise. On the other hand, high-level expert performances cannot be adequately described as individual accomplishments since they are typically based on the use of socially and physically distributed resources. Correspondingly, the view of learning that focuses only on the cultivation of individual minds may be too narrow when developing teaching–learning environments for supporting the development of expertise.

Thus we face a very challenging educational problem: How to develop learning environments which provide students with adequate knowledge and skills to deal with the complex and ill-defined problems of practical situations and at the same time facilitate the development of well-structured formal and partly abstract knowledge structures, which are not limited to any particular practical context. In addition to this the learning environments should acquaint students with the social and distributed nature of expert practices.

Particularly in institutional education, complex content areas have typically been divided into small content units that subsequently have been ordered in the list form. These lists of goals and content units have proved to be useful for teaching well-defined simple knowledge structures and fact lists, but inconvenient for learning complex knowledge structures and skills needed in solving problems, typical of professional practices. Even good mastery of the content units typically does not lead to comprehension of the complex situation, and the learning outcome remains on the level of memorized lists of isolated units. In some recently developed computer-based learning environments, the complexity of the content area has consciously been considered. One principle, which seems to be common for different approaches, is to acquaint students with the structural complexity of the tasks from the very beginning of their study career. Instead of teaching sequences of isolated content units, these environments present the students with complex problems while they are studying the sub-elements of problems (Lehtinen & Rui, 1996).

A variety of new approaches to teach students to learn more applicable knowledge structures, and manage complex and ill-defined tasks, have been developed. Different case- and problem-based methods have turned out to be effective approaches in many learning contexts. Most of these models stress authentic cases or problems, students’ self-directed learning, and collaborative processes (Schmidt & Moust, 2000). Although the studies described in the articles of this issue differ in terms of students’ age, learning aims, types of problems, and the way in which collaboration is organized, they all use the notion of problem-based learning (PBL). The term distributed PBL (dPBL) refers to the use of some kind of network-based collaboration tool during the PBL process. The approaches presented in the articles are based on some basic assumptions of PBL (Barrows, 1985; Schmidt, 1995) on the one side, and computer-supported collaborative learning tradition on the other (Koschmann, 1996). There are, however, important differences in many fundamental principles, procedures, and tools used in the studies described here.

Structure of the PBL Procedure

In its established form, PBL is typically organized according to a sequence of distinguishable steps (Barrows & Tamblyn, 1980). For example, in a typical tutorial group at Maastricht University, PBL follows a so-called “Seven Jump” procedure: (1) clarify unknown terms and
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In the dPBL models described in this issue, we can find at least three different solutions concerning the teaching–learning procedure. For McConnell, the PBL procedure is not so clearly a sequence that is planned beforehand and provided from the outside, but something that is created during the virtual collaborative process by the participants. According to his results, there were three distinct but partly simultaneous phases in the collaborative process: negotiation, division of work, and production. In addition, McConnell identified milestones that refer to certain points in the work of the group when something pivotal occurs. It is obvious that in dPBL and learning processes jointly recognized milestones are very important. It is also obvious that in network-based learning environments these milestones can be made visible for all the participants better than in traditional face-to-face group work. The milestones can be understood as temporary results of the negotiation of meaning. From the point of view of the participants the description of a milestone in the network environment can serve as a joint point of reference, which facilitates reciprocal understanding during the subsequent network discussion.

A very different approach has been taken by Steinkuehler et al. They have built, in a computer environment, a fairly strict sequence of different individual and collaborative activities belonging to the PBL procedure. In this approach the idea is that a strongly structured network environment guides students into a meaningful PBL process, even in situations in which the tutor is inexperienced in guiding tutorials, or has too little time for all the small groups. A third approach is presented explicitly in Björck’s paper. In this case the course is taking place in a “standard” network-based asynchronous conferencing system, and the teachers or facilitators guide students to follow this strongly structured eight-step PBL procedure.

The papers do not give sufficient empirical data that would allow us to make direct comparisons between the three different methods of structuring distributed PBL procedures. However, we can assume that the adequacy of the different models depends on the learning aims, the prior knowledge and experience of the students, and the tutoring resources available. One of the basic assumptions of PBL is that, when facilitated by a well-planned procedure, even students with limited prior knowledge can start dealing with complex problems. All the students in McConnell’s study were professional educators, particularly interested in open and distance learning, and they aimed at developing innovative ways to use the Internet and the Web in their teaching. It is obvious that these factors at least partly explain the promising results of the very lightly structured model used in McConnell’s study. The other papers emphasize more the importance of well-structured procedures of dPBL.

In virtual or dPBL environments there are many opportunities for pre-structured activity and interaction sequences. It is challenging to develop computer-supported environments in which
the pedagogical ideas and procedures of PBL are implemented in the structure of the software. The STEP program developed by Steinkuehler et al. is a good example of an attempt to facilitate PBL by the use of highly specialized tools. They have managed to create a network environment in which students are guided through a series of collaborative and individual activities belonging to a typical PBL process. The problem, however, is that students do not always interpret and use the computer environments in expected ways (see Järvelä et al., 2000). This problem is very likely if we attempt to implement highly complex pedagogical procedures in learning environments. The preliminary results of Steinkuehler et al. indicate that students used some of the tools in an unexpected way.

Types of Problems and Learning Issues

The quality of problems and the way they are presented have proved to be very important for the subsequent learning processes. In a review, Schmidt and Moust (2000) have emphasized that the quality of problems appear to strongly affect the functioning of the PBL groups, time spent on the study, and interest in the subject matter. According to their definition (2000, p. 28), good problems are suitable for applying systemic work procedures, stimulating group discussion, providing opportunities for formulating learning goals, and stimulating self-directed learning.

McConnell’s approach seems to conflict with the more standard idea of PBL. In his study only a very general topic was provided to the participants, and it was the task of the participating students collaboratively to formulate the problem that was then dealt with during the subsequent learning process. The idea in this paper is that the negotiation over the possible problem formulation as such is an important part of the learning process. It is not clear what kind of introduction was given to the participants, but the empirical results of the study show that this extremely open problem-solving model worked quite well. McConnell’s open problem-solving model might work in adult learning courses in which the learning aims are very general, and to some extent unspecific. This model differs very much, however, from the approaches typically used in PBL, where certain knowledge and skills are studied within the frames of a sequence of systematically designed problems.

The most characteristic feature of PBL is that it is based on authentic and complex problems. Although typical PBL problems are often somewhat similar to the problems faced in real professional situations, it is often clear to the students that these particular problem descriptions are developed for instructional purposes only and there are no real situations or projects they could contribute to with their problem-solving processes. The authenticity of the problems can be seen very differently. Very often it means that the problem situation is described in a way that refers to a real practical situation, although students know that the teachers have invented these situations. In medicine and business education it is typical to use cases that are taken from real professional situations. It is not, however, meant that the solutions produced by the student groups would have any influence on the practical situation from which the cases originate. Still, there are also examples of PBL processes in which the students’ work is tightly connected to ongoing practical problem solving and development projects. Network environments and dPBL models could give many opportunities for the future development of these kinds of methods.

In conventional PBL models, problems are typically presented in the form of written case
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descriptions. These case presentations give a limited amount of information and are static by nature. This means that the reading of a description amounting to only a few sentences is the students’ only direct contact with the cases that are underlying the problems to be dealt with in the learning process. This approach is also typically applied in the articles of this special issue. For example, Orrill used a problem in which students (education graduate students) had to work as members of a curriculum committee that is asked to develop an initiative for a large teaching reform, in which technology will be integrated in teaching. The problem was presented in the form of a letter from the Superintendent to the members of the Curriculum Committee.

Although many studies of PBL have shown that it is possible to formulate written case presentations that serve as inspiring starting points for individual and collaborative problem solving, we should consider the opportunities to create new forms for problem presentations by using technological tools (Lajoie et al., 2001; Lehtinen et al., 2001). Steinkuehler et al. used videocases of actual classroom interaction as problems to be dealt with in the collaborative learning process. These cases included episodes that the authors of the study considered as “ideal” examples of teaching–learning strategies in which current ideas of learning sciences are applied in an adequate way. In another set of videocases they presented “not-so-ideal” teaching–learning episodes. The students’ task was to give feedback on how the teachers presented in the videocases could improve their lessons. In our own study (Nurmela et al., 1999), we also used videocases of real teaching–learning interaction as a tool for problem presentation. These studies give some preliminary evidence that videocases can help students to pay attention to joint problems, even when the collaboration takes place through a network-based collaboration tool.

Computer simulations open up rich opportunities for presenting authentic problems for learning. Using well-designed, simulated, computer-generated environments a student can focus her/his attention primarily on those questions that are necessary for the theoretical and practical management of the task at hand. Covering complex problems typical to real-life work environments is very difficult for many fields of higher education, because dealing with real complex problems demands substantial investments of resources, takes considerable amount of time and may be problematic owing to the ethical and safety issues involved. Computer-based applications simulating these complex and practical problems do, however, provide us with promising opportunities for developing higher education to meet the challenges that the developing society places on future academic experts (Lehtinen & Rui, 1996). In a simulated environment it is also possible to exercise complex problem situations which are very rare in practical work, but which experts should be able to cope with immediately in practice (Lesgold et al., 1992). In many recent studies, simulation environments have been used as a tool for problem presentation in PBL. For example, Bergland et al. (2001) simulated DNA-electrophoresis to create a starting point for students’ discussion in a course on genetics, and Lajoie et al. (2001) developed a system called BioWorld to facilitate PBL among high school biology students. A limitation of typical simulation environments is that students tend to consider the simulations as artificial games.

In our own studies we have combined computer simulations and collaborative network environments to enrich (distributed) PBL. In this approach the information relating to real cases is presented with the help of a simulation environment that makes it possible for the collaborative PBL group to obtain deeper information of the particular case through multiphase
interaction with the simulation environment. The ALEL program is designed for learning of scientific experiments and analyzing their results with statistical methods. NerveGame is meant for first-year anatomy students for learning the structure and function of muscles and nerves. In addition, we have developed a simulation for presenting cases of children with infectious diseases (Lehtinen et al., 2001). All the environments share three common features: (a) they present information of real cases; (b) students have to carry out multiphase activities typical of professional practices to obtain the information; and (c) the simulations provide students with different representations of the information, and the problem-solving path they have carried out. Preliminary results show that these dynamic problem presentations facilitate collaborative problem-solving processes and a more precise definition of the learning issues by providing the student group with a joint point of reference that develops according to progress in the problem-solving process.

**Tools for Supporting Social Interaction**

One of the foundations of the PBL model is the collaborative problem-solving process and the discussions carried out in the tutorial groups. In a typical PBL process there is a conscious attempt to externalize some fundamental milestones of the individual and collaborative processes. The cognitive value of externalization in social interaction is based on a process of making internal processes of thought visible (e.g., Collins et al., 1991). From a cognitive point of view, it is particularly important to transform internal and hidden processes of inquiry into a public form in which they can be examined and imitated. Advancement of one’s inquiry can be fostered by making metacognitive processes (e.g., comprehension monitoring), which cannot normally be observed, “overt, explicit, and concrete” (Brown & Campione, 1996). Hence, it is plausible to assume that imitation of good cognitive practices, and appropriation of more advanced processes of inquiry, can be elicited by creating learning environments that mediate all stages of the process of inquiry, not just the end result. This, in turn, would allow students to become aware of their conceptual advancement, as well as of changes in their practices of inquiry.

If the collaboration takes place in a virtual environment instead of a face-to-face discussion, the guiding problems might become even more demanding. All the studies presented in this issue made use of network-based collaboration tools for asynchronous (and synchronous) virtual discussion. Most of the groupware applications support discussion forums. They enable synchronous and asynchronous collaboration by introducing a measure of structure that facilitates the process of sharing, organizing, and navigating information through an interactive electronic space. Crook (1994) makes a distinction between interacting around and through computers. The first perspective stresses the use of computers as tools to facilitate face-to-face communication between student pairs or in a small group. According to Crook (1994, pp. 189–193), in these situations technology may be serving to support collaboration by providing students with something he calls points of shared reference. He claims that a traditional classroom situation is too thinly resourced for successful collaboration. There are not enough available anchor points at which action and attention can be coordinated. The capabilities of computers can be used as mediating tools that help students to focus their attention on mutually shared objects (Järvelä et al., 1998).

Most of the computer tools used in the studies presented in this special issue are meant for
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general use, without any specific features to support PBL, but some of the tools included tailored features intended to facilitate collaboration. Ronteltap and Eurelings used a system called POLARIS as a network-based working environment in which students were able to share the documents that were based on the ideas developed basically in face-to-face interaction. The tool itself did not include any PBL-specific features, but the strong connection to the type of collaboration typical of PBL was based on the use of it, in connection with face-to-face tutorial meetings. As described above, the STEP system devised by Steinkuehler et al. provides students with specific tools intended to facilitate individual and collaborative processes during different phases of the PBL process. The system is aimed at guiding and constraining the discussion during various steps of PBL in a way that is supposed to be appropriate for the collective and individual learning process.

The ACT system used by Orrill aims to provide students with a mediation tool that not only makes a network-based discussion possible, but also shapes the quality of discussion through the predestined message labels. The idea to use labels which are related to different functions of the individual documents, messages of notes, was especially emphasized in the thinking-type approach of the CSILE system that was originally intended for young students (Scar-damalia & Bereiter, 1994). The thinking-type labels have also been used in other systems that are meant for older students (e.g., Muukkonen et al., 1999). The labeling system used by Orrill was, however, more detailed and complex than the labels used in many other collaboration tools. The results show that students are not always willing to use predestined labels. They also use the labels in an unexpected way. Although there is some evidence that a label system can facilitate higher order collaboration among young students, it is not self-evident that his approach is suitable for higher education. As Orrill remarks, adult communication is often so complex that each message contains many interrelated idea units, which may belong to different categories.

Conclusions

The papers in this issue open interesting views into dPBL. They show that the network environment, and the types of collaboration typical for these environments, can facilitate PBL processes. Although PBL is a very demanding teaching strategy for teachers and tutors, the papers give some evidence that a CSCL environment can be used to make this task a little easier by distributing a part of the tutoring role to the technology environments and to the students themselves. However, the papers do not succeed in going very deep into the possible collaboration and learning processes that take place in the network environments.

At least two issues should be considered more in future studies of distributed (network-supported) PBL. Although some of the papers presented tools which were meant to facilitate PBL-specific communication and learning processes, it is obvious that the studies have not made the most of the possibilities of network technology in presenting problems and organizing PBL discussions. Further development of distributed PBL needs more in-depth analyses of the processes taking place in these environments. More advanced methods are needed to analyze how different features of the tools and instructions influence the collaborative processes, and how the collaborative processes are subsequently related to the quality of learning at the collective and individual level.
REFERENCES


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