Content and processes in problem-based learning: a comparison of computer-mediated and face-to-face communication

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Abstract
There has been an increasing interest in the use of computer-mediated communication (CMC) in problem-based learning. One line of research has been to introduce synchronous, or simultaneous, communication attempting to create text-based digital real-time interaction. Compared with face-to-face (F2F) communication, CMC may be a poorer medium regarding coordination of the activity. Still, we are in need for more knowledge on the possible advantages and problems regarding such digital communication processes. In the present study, we compared activities in digital and F2F problem-based learning (PBL) regarding the content of the communication, turn-taking processes and the emergence of learning issues. The results indicate that when students discussed in the digital learning environment, they focused more on technical and organizational questions, produced relatively more initiatives but less responses, and produced less elaborated and specified learning issues than when they participated in F2F meetings.

Keywords
computer-mediated communication, problem-based learning, synchronous communication.

Introduction
When in need to consult a medical practitioner, probably nobody would choose a doctor with a distance education certificate. There are, at least with today’s technology, limits to what one can learn at distance. Still, there is an increasing interest in distant education within the community of medical education and especially different forms of distributed problem-based learning (dPBL) have been discussed.

Problem-based learning (PBL) has become a widespread approach to teaching and learning within medical education. The method emphasize that students should collaborate to solve ill-structured problems, while the teacher should stress facilitation rather than instruction. The learning takes place both in small groups, face-to-face (F2F) and through self-study. Lately, there has been an increasing interest in the possibility to apply computer-mediated communication (CMC) in PBL, often referred to as dPBL. This interest seems to derive partly from the increased attention computer-supported collaborative learning has received (Koschmann 1996) and partly from more pragmatic reasons, namely the chance to participate in PBL groups regardless of the students’ possibility to be on campus (Barrows 2002). It has, for example, been argued that students on placement in general practice should have access to computing facilities to undertake PBL while off campus (Hagdrup et al. 1999). However, as dPBL usually implies a text-based learning environment, a new tool for communication is being introduced, restricting the participants’ possibilities to use audio-visual cues like intonation and gaze direction to...
coordinate the discussion. In this study, we wanted to explore how the communication in PBL groups might be affected by the introduction of CMC. More specifically, we wanted to explore possible changes regarding core elements in the discussion like social interaction, work organization and the exchange structure in students’ discussion of the problem.

Content and processes in PBL

Problem-based learning is anchored in concrete and meaningful problems and organized around the investigation, explanation and resolution of such problems (Hmelo-Silver 2004). To promote hypothesis-driven reasoning, the problem should both be complex, open-ended and require students to gather knowledge from multiple sources. Students are organized in small groups of five to seven members together with a tutor facilitating the discussion in the group. The main goals of designing PBL is to help students (1) construct an extensive and flexible knowledge base; (2) develop effective problem-solving skills; (3) develop self-directed, lifelong learning skills; (4) become effective collaborators; and (5) become intrinsically motivated to learn (Hmelo-Silver 2004). A common approach starts with the presentation of a case to the group. Students have to formulate and analyse the problem relying on their prior knowledge and put forward their initial hypothesis through a phase of brainstorming. Next, the students elaborate on and evaluate the proposed hypothesis concluding on what they already know and what they need to know more about. The identification of knowledge deficiencies should result in the students’ learning issues, being explicit on what they need to learn more about before the next meeting. In the second meeting, the group meet to report and synthesize their findings, and also to reflect on what they have learned during the process.

Though several studies on PBL show mixed results regarding the outcomes, there are indications that students following a PBL programme do better on tasks requiring long-term retention, knowledge application and transfer of problem-solving strategies, than students following more traditional programmes (Hmelo & Evensen 2000; Capon & Kuhn 2004; Hmelo-Silver 2004). On the other hand, there do not seem to be any effect of PBL on measures of factual knowledge. The benefit of PBL then seems to lie in ‘the potential for greater understanding reflected in an integration of the new concept with existing knowledge . . .’ (Capon & Kuhn 2004, p. 74). This benefit may partly be explained by the fact that PBL students are expected to mobilize prior knowledge – or naïve theories – during the initial process of analysing the problem and generating hypothesis. This process makes prior knowledge explicit, and thereby easier to connect to new knowledge and to criticize and revise the preliminary naïve theories. Studies on processes in PBL groups reveal that students often focus on theory building, causal reasoning and hypothesis testing (Schmidt & Moust 2000), and that responding to and refining ideas that have been proposed are common activities. Internal processes of thought are made visible and thereby possible to examine and revise. This has resulted in more elaborated and integrated explanations of the problem at hand, than students in more traditional curricula have been able to produce (Hmelo-Silver 2004). One critical aspect of the PBL process seems to be that prior knowledge in the form of hypothesis and ideas are put forward in the group and that the group members actively respond on these ideas to revise or to reject them.

dPBL: possibilities and challenges

A central argument in favour of PBL is that social interaction in small groups is supposed to externalize hypothesis-driven reasoning, making internal processes of thought visible and thereby possible to examine and revise. It is believed that CMC may reinforce this process as written communication make thinking processes even more transparent to the members of the group, as the discussion by necessity must be explicit and articulated. Students might feel a need to think more about how they express themselves, because the discussion is saved and available for later inspection by any other member of the group. This may also encourage a more coherent process of knowledge building, as text-based communication normally is less transient than oral communication. Participants may go back to the saved discussion and further clarify and develop arguments and problems not solved during the initial discussion (Cameron et al. 1999). Still, the introduction of dPBL also seems to involve new kinds of communication problems. The loss of non-verbal signals (eye contact, facial expressions, gestures) and paraverbal cues (voice inflection, volume) in text-based dPBL may
inhibit the flow of communication. At the same time, typewriting needs more time than talking and this may cause dPBL participants to be more economic in their communication (Zumbach & Reimann 2003). In addition, results from a recent study indicated that students perceived themselves as less active in dPBL groups than in PBL groups (Strømsø et al. 2004). Though the use of text-based communication in dPBL environments could enhance participants’ level of reflection and the coherence of the discussion, this kind of communication also seems to be a poorer medium regarding the coordination of and the intensity of the activity. In accordance with this, several researchers have developed tools to compensate for the loss of communication opportunities in text-based dPBL, for example, by providing automatic feedback mechanisms (Zumbach & Reimann 2003), introducing different dialogue roles (Pilkington & Walker 2003) or by designing tools to support the problem-solving process (Friedman & Deek 2002). Such attempts to add new tools to the dPBL environment to support communication and problem solving indicate new possibilities for learning. However, in redesigning PBL into new models of dPBL, we should know as much as possible about differences between students’ communication patterns in the different learning environments. Unfortunately, there are few studies comparing PBL and dPBL (Zumbach & Reimann 2003), and our intention was to do such a comparison before effort is put into a further development of a dPBL environment.

Synchronous communication

There are two types of text-based CMC: synchronous and asynchronous communication (Riva 2001). Synchronous CMC allows two or more users to communicate simultaneously by typing messages to each other, while asynchronous communication is taking place at different times or over a certain period of time. The most widespread examples of these different kinds of CMC are chat (synchronous), where the communication is in real time, and e-mail or blogs (asynchronous) where the communication process does not depend on the simultaneous presence of the participants.

In the present study, we chose to focus on synchronous communication. This mode of CMC seems to be preferred in several dPBL studies (Cameron et al. 1999; Koschmann et al. 2003), though asynchronous CMC in general seems to be used more frequent in computer-supported learning environments. Cameron et al. (1999) actually recommend synchronous CMC as the primary mode of communication in dPBL, ‘with secondary emphasis placed on asynchronous’ (p. 3) CMC. Other researchers see real-time social interaction between learners as an advantageous feature of synchronous CMC compared with asynchronous CMC, and emphasize that synchronous CMC-based problem solving does not differ much from F2F problem solving (Orvis et al. 2002). However, as asynchronous CMC more often is the preferred mode of CMC, the arguments in favour of synchronous CMC should be grounded in results from more studies.

Garcia and Jacobs (1999) favour the term ‘quasi-synchronous’ CMC rather than synchronous, as only the produced messages and not the message production are simultaneous available to the participants in a CMC environment. This may constrain the turn-taking process in the group, as you might be occupied with message production while the other participants, unaware of your response being under production, move the discussion on to new questions. When you finally enter your message into the discussion, it could have moved away from the questions that initially elicited your response. The sequential context has changed, making it harder to interpret your message. This may obviously be a problem in the coordination of the discussion, a problem not being present in turn-taking processes in F2F communication. It could be that such coordination problems hamper certain aspects of the problem-solving process. For example Kerr and Murthy (2004) found that students using synchronous CMC generated more ideas in a problem-solving process than F2F students, but the F2F students were superior in distinguishing between relevant and irrelevant ideas. The results indicate that participants in synchronous CMC environments may feel freer to propose ideas as they do not have to face the other participants’ non-verbal objections, and they can produce ideas without any kind of interruption from their peers. In this way, a synchronous CMC environment may support the important brainstorming phase during the first PBL meeting. This phase is supposed to mobilize students’ prior knowledge through the process of generating hypothesis regarding the problem at hand. Next, these hypotheses should be elaborated and evaluated. The results from the Kerr and Murthy (2004) study indicate that the
participants using a synchronous CMC environment were less successful in discussing and evaluating the proposed ideas than students using F2F communication. These results could indicate that synchronous dPBL have the potential of supporting the generation of hypothesis in PBL, but that the next phase of hypothesis-driven reasoning in the form of discussion and evaluation may be inhibited in a synchronous dPBL environment. The possibilities for ‘parallel communication’ may make it more difficult to keep track of the discussion and to keep an overview (Veerman et al. 2000). However, these problems may be temporary. As students get more experienced with synchronous CMC, they may overcome such problems and coordinate the turn-taking process in accordance with the nature of the learning environment. Results from a study by Orvis et al. (2002) indicated shifts in communication patterns during a period of 6 months. These shifts concerned the content of the communication and not the communication process as such, but a shift from ‘mechanics of the process’ to ‘on-task’ communication may also be an indication of a shift of focus from communication problems to subject-related questions. In the present study, we chose to focus on both content categories and turn-taking processes in comparing F2F and synchronous CMC.

Learning issues

In addition to the content and turn-taking analyses, we also chose to focus on the emergence of learning issues in PBL and dPBL meetings. The process of generating learning issues should be based on students’ discussion and evaluation of hypothesis proposed by group members. As members of a PBL group are exploring the case, several questions will need explanations and some of these questions will be difficult to answer during the meeting. The participants will experience a gap between what is understood and what is not understood, and this gap should motivate them to self-directed studies outside the group. Learning issues are intended to be the manifestation of this gap, and the first meeting on a case should not be ended before the participants have formulated learning issues guiding their individual work before the second meeting. In many ways, the formulation of learning issues is the central aim of the first PBL meeting. In focusing on certain steps in this process, Koschman et al. (2003) found that participants in a synchronous dPBL group did not differ from common PBL procedures regarding the formulation of learning issues. Taking the possible communication and coordination problems in synchronous CMC into account, this result is promising, but more research is needed.

In summary, the increasing interest in dPBL is based on both the promising pedagogical possibilities in computer-supported collaborative learning, associated with the explicit nature of written discussion, and the wish to offer off-campus students a possibility to attend case-based group discussions. The introduction of dPBL implies a new tool of communication with obvious restrictions compared with F2F communication, though such tools also may offer new possibilities. Several researchers have chosen synchronous communication as a central part of dPBL, though this mode of communication may mean difficulties in keeping track of the discussion. In this study, we wanted to explore how communication in group-based problem-solving processes is affected by the introduction of synchronous CMC, regarding both the content of the discussion and the exchange structure in the discussion, by comparing students’ interaction in both PBL and dPBL. Specifically, we wanted to study whether students in a dPBL environment have to focus more on organizational matters and mechanics of the process than students in a traditional PBL environment, and whether the dPBL students are less eager to discuss and evaluate proposed hypothesis. In addition, we wanted to focus especially on possible differences between PBL and dPBL in the emergence of learning issues.

Method

The study took place in an authentic situation, where the current faculty of medicine had decided to introduce dPBL into the undergraduate study programme. Design and accomplishment of both dPBL and PBL was carried out by the faculty of medicine and not affected by the present study.

Participants and academic context

The sample consisted of 23 students in the 10th term of the medical education course at a Norwegian university. The sample included 13 females and ten males, and the students ranged in age from 23 to 32 years, with an overall mean age of 26.6 years. Prior to this term, the
students had gained extensive experience of PBL through medical studies. The study took place while the students had a 12-week period of clinical placement in rural hospitals and family practice. The 23 students were geographically distributed to nine hospitals and 23 family practices. Each family practice had only one student. Up to four students were in the same hospital at the same time. During the 12-week period of clinical placement, the students continued to work in PBL groups using a Norwegian learning management system (ClassFronter, Fronter AS, Oslo, Norway). Students in the same PBL group were never in the same location. The students gave their consent to participate in the study individually in writing.

The students were organized in three groups, two with eight and one with seven members. The three tutors were the same for both the dPBL and the PBL task. All three were experienced PBL tutors working full-time at the university. At the beginning of the 10th term, the students were given a 4-h introduction to the use of the learning management system and afterwards did practice on a PBL case for approximately 2 h. The students were given two study cases during the clinical placement period and two cases afterwards when they were back on campus. In the dPBL, the participants should download the case assignment and make preliminary notes before the first meeting. Each case included two synchronous meetings, with individual work between the meetings. In this study, we use data from the second dPBL study case. On the first meeting on the second case, 20 out of 23 students participated, while 18 participated on the second meeting. The chat service of the learning management system provided a small message field for typing at the bottom of the screen, while the rest of the screen displayed the already posted messages in a sequential manner, each message marked with the time the system received the message and the name of the sender.

The third and fourth case (campus) included two F2F meetings. Data from F2F activities were collected using video and tape recorder. Two groups were recorded working on the third case, while one group was recorded working on the fourth case. The groups were observed working on one case which involved two meetings. All students participated in the first F2F meeting, while five students were absent on the second meeting.

Under both conditions, the tutors were responsible for deciding when to end the meetings, though they should not last longer than 90 min. The dPBL meetings had a mean length of 49 min, while the mean length was 70 min for PBL meetings. Both the electronic and the F2F meetings followed the ‘Seven Jump’ procedure (Schmidt & Moust 2000), which the students were well accustomed to. This procedure include the following steps: (1) clarify unknown terms and concepts; (2) define the problem; (3) analyse the problem and produce hypothesis; (4) criticize the explanations proposed and try to produce a coherent explanation; (5) formulate learning issues; (6) fill the gaps in your knowledge through self-study; and (7) share your findings with your group and try to integrate the knowledge acquired.

The cases

According to the authentic nature of the programme, we were not able to select cases being directly comparable between the two conditions. We selected the second case for all three groups during the dPBL condition, as the participants then had the experience of working in a digital learning environment from both the training session and the first dPBL study case. For practical reasons, we had to select the first PBL case for one group and the second PBL case for two groups. However, all cases were constructed according to the same directions, stressing that the cases should be adapted to the knowledge level of the student. The cases should also be sufficiently complex and open-ended, realistic, able to trigger conjecture and argumentation, and the solution should rely on multiple pieces of information.

All three cases were related to issues within family medicine and to legal issues in medicine. Though the cases were focusing on different content, they were all designed to elicit the same kind of activity.

Data analyses

Electronic discussions were automatically logged as text files with time stamps and names per message. Data from F2F meetings were collected using video and tape recorder. The tape recordings were transcribed, while the video recordings made it possible to identify who spoke at any given time. Transcripts from the two dPBL meeting constituted 8152 words, while transcripts from the two PBL meetings represented 40 237 words.

Transcripts from both dPBL and PBL were segmented and categorized. First, we attempted to quantify
the manifest content of the meetings (Rourke et al. 2001). As unit of analysis we selected students’ utterances. Every time a students’ identification appeared in the transcript, the following utterance were identified as a message unit. This means that a unit could consist of both a single word and several sentences. After reading the transcripts once and partly inspired by Garrison et al. (2000), we decided to use the following categories in this analysis:

1 Social interactions
   1.1 Subject-related: comments that are related to medical questions or clinical placement without touching on the case/assignment.
   1.2 Small talk: comments without subject relevance, for instance, greetings, social appointments, references to leisure activities and social relations.

2 Work organization
   2.1 Technically related: logging on ClassFronter (CF), use of different CF functions, clarify time for start of session.
   2.2 Task/assignment-related: comments related to different aspects of work organization without touching on the substantial questions/problems in the case.

3 Subject/task-related
   All segments related to substantial aspects of the case.

4 Task and process evaluation
   All segments that in some way imply evaluation of the task, the group processes, organization, the tutors’ contributions.

5 Segments not possible to categorize

If a unit could be coded with more than one category, all the relevant categories were counted. Two raters (members of the research team) determined inter-rater reliability. Agreement between the two raters on a randomly selected 10% of the transcriptions was 85.6%.

To compare interaction in dPBL and PBL groups, it is desirable to analyse sequences of message units. Traditionally, dialogues in classrooms have been characterized as consisting of initiate-respond-evaluate sequences. In the present study, we applied a modified version of Pilkingtons’ DISCOUNT scheme to compare the grammar of turns, or the exchange structure, in a dPBL meeting and a PBL meeting. Here, a turn is defined as a ‘contribution by a particular participant and is delimited by them starting and stopping speaking’ (Kneser et al. 2001), and thus overlap with our unit of analysis categorizing the content of the meetings. We chose the first meeting attached to case number two in the dPBL condition and the first meeting in the campus-based PBL condition, in the same three groups. In the analyses of the exchange structure, we chose to focus on the participants interaction regarding substantial questions/problems related to the study case. That is, we chose to analyse only messages or utterances related to substantial aspects of the case, meaning segments in category 3 from the content analyses. The DISCOUNT scheme use the following categories in analysing the interaction in the groups (Pilkington 1999):

I: Initiative is the initial turn in the exchange. It predicts a subsequent turn by another participant and it is not predicted by the preceding turn.
R: Respond is a comment on previous message units (e.g. acceptance/rejection) or an answer to a question.
RC: Response complement implies comments on a response or confirmation of response by repetition.
RI: Re-initiate is comments where a satisfactory response cannot be given without first receiving a response to an intermediary question or statement.
SA: Stand alone describes the case where one participant monologues.

Two raters (one of the authors and one trained graduate student) determined inter-rater reliability. Agreement between the two raters on a randomly selected 10% of the transcriptions was 83.3%.

Finally, the protocols from the first meeting under both the dPBL and the PBL condition in all three groups were searched for explicit traces of the ‘Seven Jump’ procedure. Explicit traces were here defined as participants referring to one of the first five steps, which should make up the structure of the first meeting. These steps should lead up to the learning issues, representing the working goals for the participants’ individual work before the second meeting.

Statistical analysis

The statistical package R was employed for the data analysis. Student’s t-test or, in case of non-normality,
Wilcoxon rank sum test was used to evaluate differences in continuous variables between two samples. Significance was defined as $P < 0.05$. The effect of the PBL environment on the discussion content and interaction was analysed by mixed mode Poisson regression using the glmmPQL procedure in R. The group number, session number, environment type and discussion or interaction categories were included as fixed effects, and the student number as a random effect. To allow the desired contrast analysis, the interaction between the environment and the discussion content or interaction was decomposed into dummy variables in the regression. The parameter estimates and the variance/covariance matrix from the regression were then used to simulate the distribution of the number of utterances in each category, using the procedure mvrnorm in R. The fraction of utterances in each category was subsequently computed. Finally, the environments were compared by calculating the ratio of the discussion or interaction fractions across the two environments and finding the size of the confidence interval of the ratio which did not include unity. A Bonferroni correction was made for the multiple comparisons performed.

Results

Activity

The results indicated a much higher level of activity in the two PBL meetings (mean 111.1 utterances per student, in total 2556 utterances) than in the two dPBL meetings (mean 36.9 utterances per student, in total 849 utterances) ($P < 0.001$). The mean number of words per utterance was also substantially higher in PBL (15.7) than in dPBL (9.6) ($P < 0.001$).

Differences in content

Differences in the pattern of content categories between PBL and dPBL were analysed with Poisson regression. In Fig 1, we see that differences in social interactions concern ‘small talk’ without any kind of relevance to the subject or to the case at hand (cat. 1.2), with students in the dPBL meetings having a relative higher amount of ‘small talk’ (16.5%) than in the PBL meetings (0.5%) ($P < 0.0001$).

Understandably, technically related issues (cat. 2.1) also get more attention in the dPBL meetings (9.0%, 95% CI 5.8%–13.3%) than in the PBL meetings (0%). Because the latter is structurally zero, no direct test of the difference between the groups was performed. However, the confidence interval for dPBL is well above zero. Utterances regarding the organization of the work (cat. 2.2) seem to be equally necessary in both PBL and dPBL. While students in the dPBL meetings seemed to allocate relatively more attention to social and technical issues than students in the PBL meetings, there was less discussion regarding the study case (cat. 3) in dPBL meetings (60.7%) than in PBL meetings (89.6%) ($P < 0.0001$). Lastly, there seemed to be a small difference in relative activity regarding task and process evaluation (cat. 4), with 3.3% in the dPBL meetings and 1.0% in the PBL meetings, which, however, did not reach significance ($P = 0.03$).

As there are only three tutors, a statistical analysis of the differences in their content patterns in PBL and
dPBL cannot be performed. The data might, however, indicate that the tutors focus relatively more on work organization (cat. 2.1 and 2.2) in the dPBL setting (47% of utterances) than in the PBL meeting (17%). On the other hand, less attention is allocated to the study case (cat. 3) during the dPBL meeting (40.3%) than during the PBL meeting (76.3%). The relative amount of social interaction (cat. 1.1 and 1.2) seems to be nearly the same in both conditions (dPBL: 6.7%; PBL: 5%), while the tutors seem to focus a bit more on task and process evaluation in the dPBL meeting (5.7%) than in the PBL meeting (1.7%).

Differences in interaction

Analysis of patterns of interaction focused only on activity related to substantial aspects of the PBL/dPBL case. That is, only activity in category 3 ‘subject/task-related’ from the content analyses. As described above, this category accounted for most of the activity in both settings, though it was more dominant in the PBL meetings (89.6%) than in the dPBL meetings (60.7%). We also chose to focus only on the first meeting in both settings in all three groups. We used Poisson regression analysis to examine differences in the pattern of interaction categories between PBL and dPBL.

In Fig 2 we see that the students had a higher fraction of initiatives in the dPBL setting (25.1%) than in the PBL setting (18.4%). However, the difference was not significant ($P = 0.03$). When it comes to ‘response complements’, the pattern changed, with 9.6% in the dPBL meetings and 18.5% in the PBL meetings ($P < 0.005$). In the three other interaction categories, there were only insignificant differences between the two settings [respond: PBL (35.8%) vs. dPBL (37.8%), re-initiate: PBL (27.2%) vs. dPBL (26.9%), stand alone: PBL (0.1%) vs. dPBL (0.6%)].

The emergence of learning issues

The groups were instructed to follow the ‘Seven Jump’ procedure under both conditions. During the first PBL meeting, all three groups elected a member as a secretary, who took notes on a blackboard visible to all members. In the dPBL condition, the groups also elected a secretary and had the possibility to use a digital whiteboard to take notes. Using the whiteboard, the participants had to divide the screen between the whiteboard and the running chat. After trying this in an earlier meeting, the groups preferred to only have the running chat on the screen. Instead, the secretary took notes in a Word file and published this file together with the logged chat in the digital learning environment immediately after the meeting.

Reading the transcripts from the meetings revealed that three of the five steps in the procedure were explicitly referred to in all three groups under the PBL condition, while only one of the five steps were referred to in the groups during the dPBL meeting (Table 1).

In the PBL meetings, all groups referred to step 2 ‘define the problem’, step 3 ‘analyse the problem and produce hypothesis’ and step 5 ‘formulate learning issues’. References to these steps in the PBL groups also initiated phases in the discourse with activity relevant to
the current step. Examples of such references to the ‘problem phase’ are: ‘What’s the problem when a patient tells you . . .?’ (PBL group 1) ‘What’s the problem here?’ (PBL group 2) and ‘Let’s write up the problems’ (PBL group 3). Such initiatives were followed by several proposals of relevant problems and through discussions it was decided which problems to put on the blackboard. The process of generating hypotheses likewise ended up in a selected group of hypotheses on the blackboard. This process was initiated with statements like: ‘We don’t have any hypotheses.’ (PBL group 1), ‘Should we construct some hypotheses?’ (PBL group 2) and ‘This is not a hypothesis.’ (PBL group 3). Though learning issues occasionally were suggested early during the PBL meetings, the processes of generating and discussing problems and hypotheses normally preceded the generation of learning issues. Whenever a learning issue was suggested, the participants discussed it and elaborated on it before they decided to work on it until the next meeting. The two steps ‘clarify unknown terms and concepts’ (step 1) and ‘criticize the explanations proposed and try to produce a coherent explanation’ (step 4) were not as explicit in the transcripts from the PBL meetings as steps 2, 3 and 5. Clarification of unknown terms and concepts was not an initial step in the process in any of the groups, but rather a task the groups focused on whenever they experienced the necessity to do so during the meeting. Neither was the need to criticize hypotheses explicated in the discussion. This phase was more an integrated part of the discussion of and process of refining learning issues.

In all three dPBL meetings, processes of promoting relevant problems and possible hypothesis are less visible. Instead, all three groups start the dPBL meeting with discussions about what kind of information they need and where they can get this information. In group 1, the study case discussion is initiated with a question from one of the participants about what kind of information sources the group members should look up. Likewise, group 2 starts with suggestions about relevant information sources, while group 3 attempts to jump directly to the learning issues before they start to discuss what kind of information they need. In all three groups, the final learning issues are rooted in the discussion about relevant information and relevant sources. There are few attempts to formulate problems and no hypotheses are suggested. In this way, there is hardly any discussion about the questions that the participants want to collect more information to answer. The learning issues are also mirroring the discussion about information and sources: ‘What does the law say?’ (about responsibility for psychiatric patients) (group 1), ‘Initiatives (regarding psychiatric patients) in the local council’ (group 2).

**Discussion**

The results from this study indicate that there are differences in both the level of activity and the patterns of communication between PBL organized as F2F communication or as computer-supported synchronous communication.

When we examined the level of activity in terms of the number of words and number of utterances in both PBL and dPBL meetings, we found that the students indeed are more economic in their communication in the dPBL meetings. In the PBL meetings, students use considerable more words and utterances, and they express themselves in longer utterances. This may be due to the students typewriting skills (Zumbach & Reimann 2003) or to temporary difficulties handling a new technology of communication (Orvis et al. 2002), but probably other variables, for example, engagement (Coates et al. 2005), also are needed to explain the difference in the level of activity. These differences do not necessarily mean that there are differences in the quality of the discussion, but they indicate less elaborated questions, arguments and reflections in the synchronous dPBL meetings. As far as these limitations are rooted in questions about typewriting skills or coordination difficulties related to ‘parallel communication’, one probably can expect new generations of young people more accustomed to these kinds of
digital communication, to handle such limitations more smoothly.

When we look at what the participants communicated about, we also get the impression that the students benefited less from the problem-solving process in the dPBL meetings than in the PBL meetings. When participating in the PBL meeting, the students used considerable more time on issues regarding substantial aspects of the study case than they did in the dPBL meetings. On the other hand, they communicated more about social issues and technical questions in the dPBL meetings. Social interactions in the form of small talk played a significant role in the dPBL meetings, probably mirroring the fact that the participants already knew each other well and were used to different forms of social interactions back at campus. In the clinical placement, the learning management system replaced their normal arenas for social chatting. This, at least, indicates that the possibilities for computer-supported communication to some extent fulfil a social need for students being away from their peers.

Though the participants had an introductory course to the learning management system and did practice in groups on a study case, the online meeting generated a lot of activity regarding technical matters. The participants obviously needed to discuss and get information about technical matters and questions on how to organize the digital interaction. This tendency is in line with results from other studies (Orvis et al. 2002). However, in the Orvis et al. (2002) study, interactions regarding technical matters decreased over time as students became more familiar with the synchronous online environment. These results indicate that students need thorough training in the e-learning system before interaction on subject-related questions is started. Otherwise, one must expect that technical issues will be in focus during an initial period of a course and that less attention is paid to the study case during this stage.

The results in this study also show that the tutors allocate more attention to technical matters and work organization than to the discussion of the study case during the dPBL meetings, while their focus is mainly on the study case discussion in the PBL meetings. These results may indicate that tutors need to assign more time for planning ahead of dPBL meetings and that the structure of the dPBL meetings should be explained even more explicitly to the students before they enter the digital learning environment. To which extent this is a transient problem linked to the first experience with a new medium, we cannot answer.

The analysis of patterns of interaction could not demonstrate that the dPBL students generated significantly higher rate of initiatives than the PBL students. However, the results show the same trend as those of Kerr and Murthy (2004) where students using CMC generated more ideas – or recommendations – in a problem-solving process than F2F students. Taking initiatives or generating the initial turn in an exchange may in this case be seen as parallel to idea generating, as proposing an idea often will be an initial turn while different kinds of responses implies comments on the proposed idea. More initiatives in the dPBL setting may be seen as a consequence of the ‘quasi-synchronous’ nature of the communication (Garcia & Jacobs 1999). The possibility for parallel communication in the dPBL setting makes it more difficult to follow up on initiatives unless the communication is more explicitly coordinated. The results on the ‘response complement’ category could also indicate that groups do not elaborate on initiatives as much in the dPBL setting as in the PBL setting. A lower number of response complements in the dPBL groups indicate that sequences of message units are shorter in the dPBL setting than in the PBL setting. That is, the participants in the dPBL setting do to a greater extent discuss on the surface and do easily jump from one idea to another. This assumption was confirmed when we took a closer look in the transcripts for processes of developing learning issues.

In searching for traces of the ‘Seven Jump’ procedure (Schmidt & Moust 2000) in the transcripts, we found that the participants to a lesser degree followed this procedure in the dPBL meetings than in the PBL meetings. In the dPBL setting, the students seemed to skip the central processes of formulating relevant problems and generating hypotheses to solve those problems. Instead, they focused more on what kind of information and information sources that could be relevant to the case at hand. Generating ideas about information and sources is premature when no problems or hypothesis are formulated. In this way, the students miss the opportunity to explicitly test the relevance of prior knowledge – or naïve theories – and thereby one central aspect of PBL is lost (Capon & Kuhn 2004). This again may result in fewer opportunities to identify knowledge gaps and to formulate fruitful learning issues based on such gaps.
The design of this study does not allow us to make any clear-cut conclusions regarding the possible effect that the introduction of synchronous CMC might have on content and processes in PBL. However, the results indicate that the use of synchronous communication in dPBL may cause restrictions on students’ communication, especially in elaborating and specifying learning issues through proposing and responding to problems and hypothesis. In addition, more attention is on technical and organizational questions and less on the substantial aspects of the study case, at least for several meetings from the start. However, dPBL may offer some new opportunities. Students not being able to meet F2F for a period of time obviously enjoy a possibility to keep in contact at the social level. dPBL also represents an opportunity for tutors to make a stronger link between students’ experiences in clinical placement and the more theoretical subject matter from textbooks and lectures on campus. However, taking the results from the present study into account, one could ask if dPBL is the right tool to strengthen the link between clinical placement and campus-based teaching.

The choice of synchronous communication in CMC environments offers both restrictions and opportunities. It might be that synchronous communication only should be used in phases of idea generation, provided that these phases are guided tighter by the tutor than in the present study. In such processes, this form of communication seems to impose less restriction and more spontaneity than asynchronous communication. However, in further research, this should be studied by experimentally comparing both forms of communication. There also is a need for more research on the importance of the design of study cases, for example, by using the digital learning environment to present multimedia cases and opportunities for simulations of problem-solving processes.

References
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