Exploration of an e-learning model to foster critical thinking on basic science concepts during work placements

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ARTICLE INFO

Article history:
Received 7 June 2008
Received in revised form 4 December 2008
Accepted 14 December 2008

Keywords:
Computer-mediated-communication
Cooperative/collaborative learning
Distributed learning environments
Learning communities
Pedagogical issues

ABSTRACT

We designed an e-learning model to promote critical thinking about basic science topics in online communities of students during work placements in higher education. To determine the effectiveness and efficiency of the model we explored the online discussions in two case studies. We evaluated the quantity of the interactions by looking at quantitative data of the discussion ‘threads’ and we evaluated the quality of the discussion by content analysis of the individual messages. Both the procedural facilitation of the discussion and the instrument for content analysis were based on Garrison’s ‘Practical Inquiry model of Cognitive Presence’. Furthermore, we explored the experiences of the students and moderators by interviewing them and we organised their perceptions using the framework of an activity system. On the basis of the quantitative and qualitative data we conclude that the e-learning model was successful in establishing a dialogue among a group of students and an expert during work placements at different locations. The ‘Practical Inquiry model’ was useful in facilitating a sustained on-topic discourse involving critical thinking. Although the amount of critical thinking was moderate, the results suggest ways to increase integration and resolution activities in the online discussions.

1. Introduction

Work-based or apprenticeship learning is a powerful educational format in higher education. It can be regarded as situated learning in which practice is not conceived of as independent of learning, and meaning is not conceived of as separate from the contexts in which it is negotiated (Barab & Duffy, 2000). In designing a situated learning environment one may adopt a ‘schooling’ perspective, focusing on the learning objectives of a curriculum and situating specific content within a context of authentic activities. The emphasis of such a design will be on learning activities and how they are related to a wider practice (Mayes & de Freitas, 2004). Taking an ‘anthropological’ perspective, one might create a design focused on possibilities for community building and experiences of learners as members of a community. In this type of design, the main emphasis will be on the relationship between an individual and members of an occupational group with its own identity and role in society.

‘Practice fields’ are environments that are designed from the ‘schooling’ perspective. They engage learners in authentic tasks requiring the use of specific concepts and skills. The practices in which learners engage are ‘school’ tasks, which are abstracted from the real world, and the learning environment is separated from ‘real’ practice in time, setting and activity (Barab & Duffy, 2000). ‘Communities of practice’ on the other hand are environments designed from an ‘anthropological’ perspective. In ‘communities of practice’ groups of individuals share mutually defined practices, beliefs, and understandings over an extended time frame in the pursuit of a shared enterprise (Wenger, 1998). Here, individuals contribute to the construction of their own identity in relation to the community of practice and, reciprocally, to the construction and development of the community of practice of which they are a part (Brown & Duguid, 1991).

This study explores an e-learning model designed to be a practice field for a work placement. It is a contrived context, in which students discuss and apply well-established concepts from basic sciences, such as physiology, chemistry, biology, in resolving problems which they encounter in the course of their personal experiences in work-based learning. The e-learning model is not intended as a community of practice in which the participants, as legitimate members of an occupational group, contribute to the maintenance and expansion of the group’s knowledge base.

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Schools of engineering and medical schools aim to deliver graduates who are competent in general and professional skills, who understand what they are doing in their professional work and can justify why they are doing it. Consequently, it is important for students during work placements to have regular opportunities for reflecting on basic science concepts and for discussing their reasoning with others. For instance, when medical students are diagnosing a patient or developing a patient management plan, they may need to revisit what they learned about physiology and biochemistry earlier in the curriculum, but the demands of day-to-day practice with its main orientation to procedural and management knowledge do not facilitate reflection on and discussion about basic science knowledge. A learning environment that fosters reflection on basic sciences from the perspective of a professional practitioner is a ‘cognitive apprenticeship’, a specific ‘practice field’ in which students learn at the ‘elbows’ of experts who coach and model the desired cognitive activity (Collins, Brown, & Newman, 1989).

Not only the type of work but also the distributed nature of work placements makes it difficult for students to discuss basic science issues. During work placements students are frequently dispersed over different locations in which each individual is not only involved in different activities but also has different time schedules. Thus the opportunities for interacting with peers and group mentoring by experts are few and may depend on the use of technology.

Although distance in place and time can be bridged by two-way delayed feedback technologies, such as asynchronous computer-mediated communication, both distance education and computer supported collaborative learning (CSCL) have their specific problems.

- In distance education, where learners and teachers are separated geographically, a psychological and communication space has to be crossed, a space of potential misunderstanding between input from instructors and learners (Moore, 1993). This gap in understanding and communication between learners and teachers, the so-called ‘transactional distance’, can be bridged when interaction is facilitated by a well thought-out instructional design (Moore & Kearsley, 2005). This requires a type of interaction that is purposeful, constructive and valued by all parties concerned. This type of interaction is referred to as dialogue and in educational relationships the objective of the dialogue is to improve students’ understanding.

- In CSCL sustained on-topic discourse can be impeded by participants’ reluctance to take part in online discussions and the difficulty of formulating meaningful contributions (Luppicini, 2007). Procedural facilitation can be used to counter these inhibiting factors and was found to be useful in encouraging discussion and in enhancing the quality of discussions (Saab, van Joolingen, & van Hout-Wolters, 2007; Scardamalia & Bereiter, 1991). In a CSCL environment, procedural facilitation may take the form of online feedback provided by a teacher or supervisor (interaction) but also of features embedded in the CSCL program itself (structure). Examples of ‘structure’ features are: types or classifications that students can use to classify their contributions, sample phrases that are useful when composing a note of a certain type, or ‘anchors’ that facilitate the decision to participate in the discussion (Guzdial & Turms, 2000). ‘Anchors’ are texts, pictures etc., which capture the attention of participants in a discussion forum because they are separate from the discussion and present topics which are assumed to be of interest to participants (Fig. 1).

So a certain amount of interaction and structure is required in CSCL for sustained on-topic discourse. Both interaction and structure need special qualities to be functional in a distance education setting. Because personal feedback in CSCL often takes up a lot of scarce and expensive faculty time, a successful e-learning model for supporting discourse at a distance should strike an effective balance between procedural facilitation by a person and by a CSCL program. It should be noted, however, that measures to facilitate discourse, which are embedded in the CSCL program carry the inherent risk of an undesirable increase in the ‘transactional distance’, when the structure that is added does not meet any real need of the learners (Moore, 1993).

In order to address all these demands, we designed an e-learning model to promote dialogue and discussion about basic science concepts in small groups of peer students dispersed over different locations during work placements. The aim of the discussions is to foster critical thinking, address topics that puzzled students during their work and improve students’ understanding of basic science concepts.

![Fig. 1. A short text used as an ‘anchor’ at the start of the second week to tease students to address the problem definition they chose at the end of the first week.](image-url)
The first aim of this study is to explore different aspects of the interactions and cognitions in small groups of learners who are using this e-learning model in the setting of a work placement. More specifically, we want to evaluate:

- the quantity and quality of interactions between participants using the e-learning model during a work placement;
- the quality of the discussion by examining if the discussions within the e-learning model attest to critical thinking.

We have framed the quantitative analysis of interactions and cognitions within the holistic context of two qualitative case studies so as to avoid the flaws which Mason described for isolated quantitative or qualitative studies of computer conferencing (Mason, 1992).

The second aim of this study is to evaluate the experiences of students and moderators with this e-learning model. We do so by seeking answers to the following questions:

- How do students perceive the learner– learner, learner–instructor and learner–interface interactions and how do they value these interactions? Are the interactions perceived as purposeful in the sense that they foster critical thinking and understanding of basic science concepts? Do the students find the e-learning model responsive to their needs?
- Do teachers perceive the e-learning model as enabling them to moderate online peer groups effectively and efficiently? Do they think the e-learning model stimulates critical thinking and improves students’ understanding of basic science concepts?

2. Methods and materials

2.1. Setting and research design

In years 5 and 6 of the undergraduate curriculum of Maastricht Medical School, the Netherlands, students disperse over different locations for 12 mandatory and two elective clerkships. For this study, we formed two ‘virtual groups’ which were randomly selected from a group of students scheduled for elective clerkships in the same discipline but in different hospitals during the same period. Both groups consisted of four students, one from each of four hospitals. Participation was voluntary and all students consented to take part in our experiment. We interconnected the students via the Internet and a CSCL program. In these ‘virtual groups’ the students used asynchronous computer-mediated communication to discuss pathophysiological concepts in a paediatric workplace setting.

We used a quasi-experimental design in which both quantitative and qualitative data were collected to explore the effects of the implementation of the e-learning model on the following broad constructs: interaction (Wagner, 1994; Yacci, 2000), critical thinking (Duffy, 1998; Pithers & Soden, 2000), and transactional distance (Moore, 1993) within a small group of distributed peers. A pre-test with the California Critical Thinking Disposition Inventory (Facione, Facione & Sanchez, 1994) showed that the groups were comparable with regard to attitude towards critical thinking.

2.2. e-Learning model

The two virtual groups were asked to use the same e-learning model halfway through an 18-week clerkship in November 2006 and March 2007, respectively. During a three-week period, in which the highly demanding regular training programme continued as usual, the distributed peers engaged in distance conversations on pathophysiological topics relating to preselected themes (cardiovascular and respiratory physiology) and originating from their personal experiences in the hospitals. The conversations were enabled by asynchronous computer-mediated communication and were moderated online by an expert (paediatrician). Each group was moderated by a different paediatrician with expertise in the relevant pathophysiological topics. The two moderators did not supervise the students during their work placements. They had no previous experience with online moderation but were experienced tutors in problem-based learning.

Because we agree with Duffy that critical thinking is an effortful, often difficult process, which can benefit from support to help students stay focused on the process and structure of an inquiry (Duffy, 1998), we used the Practical Inquiry model of Cognitive Presence (Garrison, Anderson, & Archer, 2001) as the framework for the discussions. In this model, the process of critical thinking is defined as cognitive activities geared to four consecutive phases: triggering event, exploration, integration, and resolution. Students’ authentic questions and previous knowledge of the phenomena under consideration are used as starting points for the process of deepening understanding, which involves finding evidence in scientific sources, building consensus on a hypothesis and applying newly acquired knowledge in thought experiments or in real practice. Table 1 shows how we operationalised the Practical Inquiry model in the online support features of the CSCL program.

2.3. Procedures

The three-week experiment started with a face-to-face introductory session in which the students and the paediatricians were introduced to each other, the CSCL program, and the Practical Inquiry model. After this session, the participants did not meet face-to-face again and communicated exclusively online via the CSCL environment. The student roles in the ‘virtual’ groups during the asynchronous conversations were distributed in such a way that all students acted as starters of a triggering event by introducing an issue they had personally encountered in real practice and found puzzling. In the first week of the online discussion each triggering event was expected to result in a well-defined problem. Only one of these problem definitions was then selected by the group as a topic for in-depth discussion during the second week. In this discussion each student was both inquirer and hypothesis builder. In the third and final week each student contributed to the underpinnings of the hypothesis which the group until then had been developing mainly based on prior knowledge. To support their hypothesis and fill important gaps in their knowledge the students consulted non-prescribed external resources, such as books, articles and/or experts.

The paediatricians acted as moderators and tried to keep the conversation alive, in-depth and focused on the generated questions and hypothesis. The moderators strove to transfer the responsibility for the discussion to the students and act as meta-level process organisers and evaluators rather than equal participants in the process (co-inquirer). In accordance with the literature on feedback (Kulhavy & Wager,
Table 1
The ‘knowledge types’ (KTs) in the CSCL program are in line with the Practical Inquiry model. The checklists and descriptions support the students in the use of these ‘knowledge types’.

<table>
<thead>
<tr>
<th>KT</th>
<th>Checklist</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Problem definition</td>
<td>– Are you contributing experiences that are salient to you and that you would like to examine in-depth?</td>
<td>– In this contribution you introduce experiences relating to biomedical features which you find confusing and difficult to understand or which you would like to have explained for different reasons. Your contribution is intended as an appeal to the other group members to help you clarify your problem and to discover whether your problem can be described in such a way that others understand and recognise it and consider it a relevant topic for discussion.</td>
</tr>
<tr>
<td></td>
<td>– Are you trying to describe the matter that is puzzling you in such a way that it is gradually becoming clearer what the core problem is?</td>
<td>– You can also use your contribution to follow-up on a problem that has already passed through a round of critical discussion but which has raised specific issues that are new to you and which you would like to elucidate. In this way your contribution can be the starting point for deepening and refining knowledge obtained in an earlier discussion cycle.</td>
</tr>
<tr>
<td></td>
<td>– Are you gradually moving to a problem definition?</td>
<td>– Are you trying to formulate the problem in such a way that it will be interesting for the group to pursue in the discussion?</td>
</tr>
<tr>
<td>(2) Exploration</td>
<td>– Are you trying to express your thoughts (interpretations, hypotheses, and theories) as clearly as possible so that the others can understand them?</td>
<td>– Are you contributing experiences that are salient to you and that you would like to examine in-depth?</td>
</tr>
<tr>
<td></td>
<td>– Are you asking questions to analyse the problem and map it out clearly?</td>
<td>– Are you trying to explain all this to the group in your own words?</td>
</tr>
<tr>
<td>(3) Integration</td>
<td>– Are you looking for connections between theories by comparing ideas?</td>
<td>– Are you trying to ascertain the relevance of the suggested ideas for resolving or explaining the problem under discussion? And do you make suggestions for theories on which the group should be concentrating?</td>
</tr>
<tr>
<td></td>
<td>– Is the group trying to determine which knowledge is ‘completely missing’ (gaps) or in need of ‘sound underpinnings’?</td>
<td>– Are you trying to express your thoughts (interpretations, hypotheses, and theories) as clearly as possible so that the others can understand them?</td>
</tr>
<tr>
<td>(4) Verification and resolution</td>
<td>– Are you searching for ‘evidence based’ theories and are you trying to explain the evidence as concretely as possible to the other group members?</td>
<td>– Are you contributing experiences that are salient to you and that you would like to examine in-depth?</td>
</tr>
<tr>
<td></td>
<td>– Are you comparing different ‘scientific’ theories and do you give your opinion as to which theory you think is superior?</td>
<td>– Are you comparing different ‘scientific’ theories and do you give your opinion as to which theory you think is superior?</td>
</tr>
<tr>
<td></td>
<td>– Are you applying newly gained insights to the problem and does that lead to resolutions, predictions, or conclusions?</td>
<td>– Are you looking for connections between theories by comparing ideas?</td>
</tr>
</tbody>
</table>
3.1. Logged postings

To gain an impression of participants' behaviour in the CSCL environment we analysed the logged postings quantitatively and qualitatively on the levels of threads and messages. We assessed the quantity of the interactions between the participants (students and moderators) by looking at the 'threads', the sequences of responses to an initial posting. We collected several types of quantitative data: the number of postings (or messages) in the discussion threads, the number of times students viewed messages posted by other students or the moderator and the number of students posting two or more messages in the same thread. Long threads (exceeding five messages), high viewing rates and repeated postings by students in the same thread suggest that students are genuinely engaged in social activity (Kay, 2006).

We assessed the quality of the discussion by a content analysis of the verbal interactions using a coding scheme developed by Garrison (Garrison et al., 2001) based on the Practical Inquiry model of Cognitive Presence. The unit of analysis is the complete message of a posting. Based on 'descriptors' (general attitude) and 'indicators' (examples) of socio-cognitive processes, messages are assigned to one of four categories: triggering event, exploration, integration and resolution (Garrison et al., 2001). This means that both the procedural facilitation of the discussion and the instrument for content analysis of the online texts are based on Garrison's model.

We used Garrison's coding scheme because the granularity of the categories makes it suitable for general educators who can use it after limited training. Another reason for using this scheme is the availability of reported interrater reliabilities, with Cohen's kappas ranging from 0.57 to 0.74, (Fahy, 2002; Garrison et al., 2001; Kanuka, Rourke, & Laflamme, 2007; McKlin, Harmon, Evans, & Jones, 2002; Meyer, 2003; Schrire, 2004, 2006), whereas there are many other coding schemes for which this information is not available. (de Wever, Schellens, Valcke, & van Keer, 2006). Furthermore, the complete message as the unit of analysis in this coding scheme provides an authentic subdivision of texts, preventing discussions among researchers about how to parse the text.

Several researchers (Kanuka et al., 2007; Schrire, 2004) have indicated that the last two of the four phases of Cognitive Presence (triggering event, exploration, integration and resolution) represent critical thinking. Exploration is an antecedent of these higher levels of Cognitive Presence but cannot itself be seen as critical thinking. This is plausible because brainstorming, which is ubiquitous in the exploration phase, is characterised by postponement of critique.

Because the e-learning model under study is based on a student centred approach, the analyses focused on the texts produced by the students. The messages posted by the students during the three-week period were analysed for each week separately (timeline analysis). Because the categories of the labels which the students attached to their messages before submission in the CSCL environment were the same as those of the coding scheme (problem definition, exploration, integration, verification and resolution, and other), we masked the labels for the coders. The messages (n = 92) of the second group were classified by two coders, which enabled us to determine the interrater reliability of the coding scheme: a Cohen's kappa of 0.65, a value interpreted by Landis and Koch as substantial interrater agreement (Landis & Koch, 1977).

3.2. Recorded interviews

In the week following the three-week period of online discussions, we conducted individual telephone interviews with all the students to explore their perceptions of the discussions. In the same week we conducted individual structured interviews with the two moderators to explore their perceptions. All interviews were recorded and transcribed. The semi-structured interviews addressed many different inter-related aspects of the e-learning model within the context of workplace learning. Because we wanted others to be able to check the representativeness and validity of the data while also aiming for a structured presentation of the data, we organised the data according to the framework of an activity system developed by Engeström (1987). This framework was demonstrated to be effective in describing the experiences of students and teachers using technology in higher education (Issroff & Scanlon, 2002) and work-based activities (Collis & Margaryan, 2004).
An activity system is a framework placing human action in a meaningful context. The three main elements of the framework are: the subject (actor in the activity), the object (product acted on by the subject) and the community (social cultural context in which the activity takes place) (Engeström, 1987). In this study, the e-learning model is seen as the activity system in which the students and moderators are the subjects, the pathophysiological problems they encounter the objects and the virtual group during the work placement the community.

Subject, object and community are interrelated by three other elements: tools, rules and division of labour (Engeström, 1987). The tools (in this study the CSCL program) mediate the relation between the subjects (students and moderators) and the objects of activity (pathophysiological problems), the rules (in this study the Practical Inquiry model and labelling messages) mediate the relation between the subjects and the community (virtual group during a work placement) and the division of labour mediates the relation between the community and the objects (not explicitly used in this study).

Finally, an activity is motivated by the need to transform the object into an outcome. In this study, the main objective of the activity system is acquisition and application of basic science knowledge. Fig. 3 shows how an activity system is often depicted as a triangle containing the seven aforementioned elements.

4. Results

4.1. The quantity of the interaction between participants

Over the three-week study period, the virtual groups of four students and a moderator posted a total of 88 (group 1) and 110 (group 2) messages. The students posted 76% of the messages in the first group and 84% of the messages in the second group. Fig. 4 shows the number of messages in the threads during the three-week period for both groups. The median values (thick horizontal lines in the tinted boxes) range from 2.5 messages in group 1 in the first week to 14.5 messages in group 2 in the second week. Because there were only two threads in the discussion in group 2 in week two, one with 26 messages and one with three messages, the interquartile range (tinted box) in this week is very large. The percentage of threads containing 5 or more messages (indication of student engagement in social activity) was 40% in group 1 and 75% in group 2.

Fig. 5 presents, for both groups separately, the number of times messages posted by one student were viewed by other students. Fig. 6 shows how many times students viewed messages posted by the moderator. For the interpretation of the values in Figs. 5 and 6, it is important to bear in mind that a student’s posting can be read by a maximum of three students, while a moderator’s posting can be read by all four students in the group. In group 1, student postings were viewed an average of 1.9 times per potential viewer and moderator postings were viewed an average of 1.6 times per potential viewer. The corresponding figures in group 2 were the same for student and moderator postings, namely 1.8 times per potential viewer. The lowest viewing rate of a student posting (bottom horizontal line in plots) in group 1
was 2 (in weeks two and three), but this concerned only three of the total of 67 messages. The lowest viewing rate of a student posting in group 2 was three, which is equivalent to the total number of potential viewers. So in this group every participant in the online discussion viewed all the postings of the other participants at least once. Nearly all of the outliers in Fig. 5 (asterisks in the plots) concerned the first posting at the start of a new week.

In addition to intensively reading each others messages all students also posted frequently messages in the discussion. So there were no ‘lurkers’, students reading messages of others without contributing with postings themselves. In group 1 the average number of postings per students during the three weeks was 16.8 messages, with a range from 13 to 21 messages. For group 2 the average number was 23.0 with a range from 20 to 26 messages. Fig. 7 presents the number of students posting two or more messages in the same discussion thread.

In all weeks, the interquartile ranges were larger for the second group than for the first group.

4.2. Quality of peer interaction

We performed content analysis of the texts of all student messages using Garrison's coding scheme (Garrison et al., 2001) in order to explore whether the discussions in the e-learning model attest to critical thinking. The following three messages illustrate how the researchers applied Garrison's coding scheme to the student postings.

(1) ‘Exploration’ message:
"Before birth the partial oxygen pressure of blood in the umbilical vein is a little below 5 kPa (35 mm Hg). After mixing with venous blood in the VCI the pressure decreases to 3 kPa (22 mm Hg). Foetal oxygen saturation in the ascending aorta is 60%.”

This text reflects the socio-cognitive process ‘information exchange’ which belongs to Garrison’s ‘exploration’ phase.
(2) *Integration* message:

“I think this is quite accurate. I don’t know exactly how much blood flows from RV to the lungs and then ends up in LV. But it is a very small portion I think. This fits with what you see in ECGs of infants. For, I think, the axis of the heart shows a relative rotation towards the right at first and later this is compensated for by a stronger development of LV.”

This text reflects the socio-cognitive processes ‘convergence among group members’ and ‘connecting ideas, synthesis’. Both processes belong to Garrison’s ‘integration’ phase.

(3) *Resolution* message:

“The transitional circulation of the preterm differs from the term infant. Higher risk of hypotension and low syst blood flow due to failure or delay in the normal transitional circulation processes. The maintenance of normal tissue oxygenation requires maintenance of syst blood flow and normal blood oxygen levels. Reduction in either of these can result in organ damage: IVH, longer term neurodevelopmental disability. –Kluckow M. Low systemic blood flow and pathophysiology of the preterm transitional circulation. Early Hum Dev. 2005 May;81(5):429-37. So postponing clamping can provide a bigger blood volume and a higher blood flow and less hypotension, and is therefore certainly advisable for preterm infants.”

This text reflects the socio-cognitive processes of ‘testing solutions’ and ‘defending solutions’ for which an external scientific resource is used. Both processes belong to Garrison’s ‘resolution’ phase.

Table 2 presents the distribution of student messages in the three-week discussion over the categories: triggering event, exploration, integration and resolution. The last column, labelled ‘other’, contains messages that were not content-related but merely procedural or social in nature. The students posted a total of 159 messages over the three-week period (Table 2 bottom row). Of these messages, 91.8% was content-related: 40.9% was categorised as exploration, 27% as integration and 7.5% as resolution. The remaining 8.2% concerned social talk or comments on the collaborative process or the use of the computer program and was categorised as ‘other’.

### 4.3. Students’ perceptions

This section presents quotations from the individual interviews with all students (n = 8) participating in the study which we conducted after the three-week study period. When opposite perceptions were revealed we tried to include illustrative quotes for both perspectives.

<table>
<thead>
<tr>
<th>Number of student messages</th>
<th>Distribution over categories (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trigger</td>
</tr>
<tr>
<td>Group 1</td>
<td></td>
</tr>
<tr>
<td>Week 1</td>
<td>21</td>
</tr>
<tr>
<td>Week 2</td>
<td>28</td>
</tr>
<tr>
<td>Week 3</td>
<td>17</td>
</tr>
<tr>
<td>Total</td>
<td>67</td>
</tr>
<tr>
<td>Group 2</td>
<td></td>
</tr>
<tr>
<td>Week 1</td>
<td>49</td>
</tr>
<tr>
<td>Week 2</td>
<td>24</td>
</tr>
<tr>
<td>Week 3</td>
<td>19</td>
</tr>
<tr>
<td>Total</td>
<td>92</td>
</tr>
<tr>
<td>Groups 1 and 2</td>
<td></td>
</tr>
<tr>
<td>Weeks 1–3</td>
<td>159</td>
</tr>
</tbody>
</table>

Fig. 7. Repeated contributions in the same discussion thread.
The quotations are clustered under six elements of an activity system (Engeström, 1987): subject, object, community, tools, rules and outcome. The letters and numbers at the end of each quote refer to student (St1-4) and group (Gr1-2).

(1) **Subject (actors in activity: students and moderators)**

Students said they highly valued the input of their peers in the discussion, although some were disappointed by the low frequency of postings. Opinions varied with regard to the quantity and quality of the moderator postings.

> My fellow students asked questions that were just as useful as those posed by the moderator. The questions posed by students are often more practical, questions that you might ask yourself: I saw a patient who had this, how come? Or: you may say this but in clinic I saw that, how come? The moderator’s questions were more theoretical, creating depth. You need both. (Gr2, St2)

At first I participated very enthusiastically but when not everybody is posting frequently, you find that it tends to come last in an overloaded programme and that in itself is a shame. This would not happen if it was an obligatory component of the curriculum. (Gr1, St2)

The moderator could challenge us for he is a role model for us obviously, being a paediatrician, and I think most of us wish to be one as well. (Gr2, St1)

The moderator’s comments might have been not so much more frequent but more pertinent. Not just in the discussion like: this does not make sense, you should look a bit further … (Gr1, St1)

(2) **Object (products acted on by subjects: pathophysiological problems)**

According to the students, the online discussion increased their interest in pathophysiology and deepened the elaboration of this topic.

> You study the material in more depth. When you are reading things by yourself you often just accept things. When you talk about it in this way you think: well what I thought was so simple, may be not so simple after all. Because you see other perspectives, how others may think about the same topic. (Gr1, St4)

(3) **Community (social cultural context in which the activity takes place: virtual group during work placement)**

Most of the students said that they felt part of a community in the virtual group and felt safe to share their thoughts within this community.

> I did feel that we were working together on something. We are all in the same situation, a clerkship and apart from that working together on something different. That was a really good feeling I think. That you are really part of a group. (Gr1, St4)

I appreciated the openness of the online discussion. Especially in the exploration phase everyone was able to say what they thought and I felt free to think aloud. Maybe even more than during live brainstorming. Then everybody reacts and your words and train of thought get interrupted much more quickly. (Gr2, St1)

During the online discussion you were really free to write what you wanted and there was no disapproval from the others, you really felt that. Yet sometimes I felt inhibited to write my thoughts down. Maybe because I think that I should have known it already and because it is really final when you write something down. When you say something in a normal discussion and it is not correct, it is somehow easier … (Gr1, St4)

(4) **Tools (online environment that mediates the activity: CSCL program)**

Several students said that the CSCL program (FLE3) had failed to give them a good overview of the unfolding discussion.

> I felt that in the program the structure of the discussion got lost after a while. When there were many postings and I opened the context of a week, you got a whole list of comments and I lost track of what it was about and what I had yet to respond to. (Gr1, St2)

I thought it was awkward that when I was posting a message I could not really get an overview of what all the others had said. You can view the posting you are responding to but not the postings before it. It would be useful when you could look back as you are typing and that was not possible. (Gr1, St1)

Furthermore, some students found the timing of the asynchronous discussion troublesome. With response times (the time between posting and response) exceeding 24 h for 47% and 57% of the responses to student postings in groups 1 and 2, respectively, students who were in the habit of checking the discussion board several times a day were annoyed that they had to wait so long for the others to respond. The variability of response times caused another timing problem as well: participants missed the opportunity to join in the ‘forefront’ of the discussion.

Unfortunately, I was unable to look that evening and the next morning was too busy and then there was no chance until the end of the following day. At that point there had been a whole discussion about your point in which you had been unable to participate. I really hated that. (Gr2, St1)

(5) **Rules (rules that constrain the activity: Practical Inquiry model, labelling messages)**

Almost all students said that the Practical Inquiry model provided a valuable structure to the online discussion and that this structure was responsive to their needs.
4.4. Moderators’ perceptions

This section presents quotations from the interviews with the two moderators. When opposite views were revealed we have tried to give an illustrative quote for both perspectives. The quotations are clustered under six elements of an activity system (Engeström, 1987)

(1) Subject (actors in activity: students and moderators)
Both moderators said they had to get used to the different dynamics of asynchronous online discussion. They perceived both advantages and disadvantages compared to face-to-face discussions.

Online the group process is different: everybody is working with the material on their own and at different times. I have the feeling that students are less inclined to simply repeat what the others have said in the discussion than they are in a f2f tutorial. (Gr2, M2)

I am the kind of person who enjoys entering into an oral conversation with others. In f2f discussions I generally maintain a good overview of everything that is being said in group and I can give responses that are to the point. I missed that overview in the online discussions. (Gr1, M1)

(2) Object (products acted on by the subjects: pathophysiological problems)
One of the moderators said that addressing pathophysiological theory during clerkship was valuable for both students and supervisors.

Online discussion about pathophysiology is valuable both for me and the students. For me because I notice that a student takes the initiative to go back to topics and notes from Year 3, which enables me to add that she might also have a look at Year 1 where respiratory physiology was first addressed. And now it recurs in the clerkship: the curriculum is not an incoherent jumble after all. (Gr2, M2)

For students it is particularly valuable that they are much more encouraged to think about the underpinnings of certain treatments. When you do that when you are treating a patient, you have a better understanding of why you do certain things and refrain from doing others. (Gr2, M2)

(3) Community (social cultural context in which the activity takes place: virtual group during work placement)
One of the moderators said he felt part of a community during the online discussion. Like the students he stressed that for the e-learning model to be feasible it is of the essence that the online discussion must be recognised by the organisation as a legitimate learning activity and integrated into the regular schedule of work discussions.

I felt a very strong involvement with the group. You make a commitment to these students and that is why you feel responsible. Another type of commitment arises later and more from the group process: you see students making an effort, often in the evenings. Most of them are committed. It is quite evident, however, that one student is doing more in one week and another student in another week. That is probably due to workload and schedules. (Gr2, M2)

This time the hours I spent on the online discussion were mostly in evenings and weekends. These are extra and they are hidden hours: the department head does not know about it, as a matter of fact nobody does. If you would want to implement this structurally in an acceptable manner it should be given much greater visibility. (Gr2, M2)

(4) Tools (online environment that mediates the activity: CSCL program)
Both moderators experienced navigation problems with the CSCL program and said they felt that the overview of the threaded discussion should be improved. They expressed different opinions regarding the overall efficiency of the CSCL program for discussing basic science concepts. One moderator said it was ‘not at all’ efficient and the other one said ‘yes’, it was efficient but less so for wrapping up the discussion and for reaching consensus about organisational matters.

Wrapping up an online discussion is tricky. In a f2f discussion you spend the last 10 minutes answering different questions. You say: there are probably some loose ends left, ask away. Online you miss that sort of wrapping up. There you end with a summarisation, but the discussion...
thread often has multiple branches and there are loose ends in many different places. Those are not easy to combine in one summarisation. (Gr2, M2)

Apart from reading the postings, working with the program took up a great deal of time. I spent a lot of time searching and had to do a lot of up and down clicking and scrolling. Altogether it took up far too much time and it was not efficient at all. (Gr1, M1)

(5) Rules (rules that constrain activity: Practical Inquiry model, labelling messages)

One of the moderators observed that implementation of the e-learning model and incorporating it into clinicians’ normal working schedules would require more central planning from the moderator.

What I have now done mostly in my free time, I might also schedule within an average working week. For instance, I might schedule 30 minutes at a fixed time to look in the system. In a similar way in which I deal with my email now. This does require more central direction, however, about which you would have to make arrangements with the group in advance. (Gr2, M2)

(6) Outcome (transformation of the objects: the overall intention of the learning activity)

Both moderators (although to different degrees) said they thought the e-learning model improved students’ understanding of basic science concepts, more particularly this transfer to clinical practice.

Apart from awareness that pathophysiology knowledge does have a function, they also gain knowledge from the discussions, which to my mind will be retained longer. They are getting away from mindless rote learning and I feel that what they learn will be much more firmly embedded in their clinical reasoning and actions. (Gr2, M2)

Physiological knowledge does not really gain more depth as a result of the discussion. They are using basic physiology which they learned in the first three years. But they do use this knowledge now for practical purposes and that does raise it to a higher level. (Gr2, M2)

5. Discussion and conclusion

5.1. Quantity and quality of the interaction

Despite the fact that the e-learning model was added to students’ considerable workload in a demanding work placement and participation was voluntary – conditions that would seem unlikely to favour strong involvement (Oliver & Shaw, 2003) – the students’ input in the online discussions was satisfactory: eight students posted 159 messages over the course of three weeks. This is 6.6 messages per participant per week. When we calculate similar figures for studies referred to in the methods section which reported sufficiently detailed information (Garrison et al., 2001; Kanuka et al., 2007; Schrire, 2006) we find between 0.6 and 4.8 messages per participant per week.

More important than the absolute number of students’ contributions are quantitative indications for engagement in social activity: long threads, high viewing rates and repeated postings by the same students in the same thread (Kay, 2006). The number of postings in most threads exceeded five messages; 98% of student postings were viewed by all other students in the group and students posted two or more messages in many of the threads. In addition the students generated 80% of all postings and peers read these messages as often as they did the moderator’s postings. In all, the quantitative data point to substantial social activity on the discussion board (Kay, 2006).

Data from the student interviews support this impression of substantial social activity. Most students valued the input of their peers highly and thought the number of messages sufficient, although the timing of postings was often problematic. Some students were annoyed when they found themselves checking in vain for updates when response times were long; others were frustrated because they missed the ‘forefront’ of the discussion. These two effects emphasize that the delay in communication characteristic of asynchronous media can be both a strength and a weakness (Hammond, 2000). A feature in the CSCL program, which automatically alerts the poster of a message to incoming responses might easily alleviate some of the aggravation induced by delay in responses.

5.2. Quality of the discussion

The occurrence of a social activity, even if it is appreciated by peers, is in itself no guarantee that higher order thinking or knowledge-building will take place (Crook, 1996; Fauske & Wade, 2003). The content analysis of the student messages with Garrison’s coding scheme (Garrison et al., 2001) enabled us to reflect on the quality of the discussion.

Table 2 shows that 91.8% of student messages in the CSCL environment were content-related. This percentage is quite high compared to percentages reported in other studies using the same coding scheme (Fahy, 2002; Garrison et al., 2001; Kanuka et al., 2007; McKinley et al., 2002; Meyer, 2003; Schrire, 2004, 2006). A finding that is similar to the results of these other studies is that the bulk of the messages was categorised as exploration (40.9%) while the percentages of integration (27%) and resolution (7.5%) were low.

Our results appear less disappointing when we compare them to figures from the aforementioned studies, although the percentage of higher order thinking activities generated by our e-learning model (34.5%) is lower than we had hoped. Our 34.5% is higher than the 20.2% (14.7% integration and 5.5% resolution) reported by Kanuka et al. (2007), who studied instructional methods specifically developed to help learners move to higher levels of learning. Furthermore, unlike most of the other studies, the setting of our study was outside the domain of educational or computer science studies. In the latter settings, computer-mediated communication will be an important topic of study in itself and populations may be expected to be biased in favour of online learning.

The percentages we found for integration and resolution messages are in line with those reported by Meyer (2003) (22% integration, 7% resolution) and Schrire (2004, 2006) (33% integration, 9% resolution), but unlike our results, these percentages included moderator postings. Because summarising and wrapping up are often seen as important tasks for the moderator, inclusion of moderator postings may have elevated the numbers of integration and resolution messages in those studies.

A very remarkable finding is that the timeline analysis shows that it is possible to steer the type of contribution by dedicating a certain week to a specific phase of the Practical Inquiry model. The third week of our online discussion was dedicated to ‘verification and resolution’ and the students in groups 1 and 2 together generated on average 33.3% integration and 33.3% resolution messages in this week. If we
look at the groups separately, we see that these proportions may even increase as a result of the moderator’s approach. Group 2, whose moderator appeared to be somewhat more inspiring, generated 42% for integration and another 42% for resolution messages in the last week (Table 2), although both groups had comparable scores on attitude towards critical thinking in the pre-test.

Garrison et al. (2001) suggested some explanations for the relatively small numbers of integration and resolution postings. One of these explanations is that composing an integration message requires more time for reflection and synthesis, which is generally considered to discourage participants from posting such messages. Another take on this might be that the inductive process involved in writing an integrative message causes participants to produce relatively few messages presenting an elaborated synthesis rather than numerous messages presenting disjointed items. So it may be a characteristic of integration messages that their number is relatively small compared to that of exploratory messages.

This inherent condensed nature could also apply for resolution postings. Moreover, before posting a resolution message participants will have to search and read the literature to find arguments underpinning the resolution message. With a limited timeframe of one week it seems only to be expected that there are only few messages per participant. Because many students said in the interviews that the ‘problem definition’, ‘exploration and integration’ phases were somewhat long compared to the ‘verification and resolution’ phase, extending the latter phase to 1.5 weeks at the expense of the other phases might be a good option to increase the number of resolution postings.

5.3. Experiences of students and moderators with the e-learning model

The students found that the e-learning model increased their interest in pathophysiology and that the online discussions guided by the Practical Inquiry model resulted in deep elaboration of pathophysiological topics which they encountered in practice. In addition the e-learning model was sufficiently responsive to give the participants a sense of belonging to a community in which they could pursue shared and personal goals.

Both moderators (although to different degrees) said the e-learning model improved students’ understanding of basic science concepts, especially the transfer of knowledge to practice. However, they expressed opposing views regarding the efficiency of the e-learning model. One moderator said he would not adhere to the e-learning model because of its inefficiency, the other moderator said it was very feasible but suggested that it should be complemented by synchronous communication. He thought a scheduled and collective meeting via videoconferencing (a sort of ‘beeper’ moment), integrated in the existing asynchronous communication, might solve the problems he had experienced with wrapping up the discussion and reaching consensus on organisational matters.

Students and moderators experienced navigation problems with the CSCL program (FLE3) and lost their overview of the threads in the course of the discussion. Improving the interface of the CSCL program by inline editing and more integration of the features to sort, nest and filter messages in the threaded discussion, might address this apparent shortcoming of the e-learning model.

It is striking that students as well as moderators advocated that the medical school should show recognition of the value of online discussion on basic science topics by integrating this format in the regular schedule of work placements. They claimed that formal recognition by the institution was essential for the feasibility of the e-learning model.

A limitation of this study is the small number of participants, and replication studies with more groups of students would be needed to enable statistically valuable conclusions.

In summary, we conclude that Garrison’s ‘Practical Inquiry’ model appears to be a viable instrument for procedural facilitation of online discussions about basic science concepts among small groups of students engaged in busy work placements at different training sites. An e-learning model integrating this ‘Practical Inquiry’ model in concerted facilitation by a human moderator and a program for asynchronous communication appeared to be successful in establishing a dialogue among an expert and a group of students. The structure of the e-learning model was useful in facilitating a sustained on-topic discourse involving critical thinking in a group of peers. Despite the moderate amount of critical thinking, the results suggest ways to increase integration and resolution activities. This might be achieved by changing the amount of time allocated to the different phases of Practical Inquiry in the CSCL program. Adding a synchronous component to the e-learning model might be another modification worth considering.

Acknowledgement

The authors thank Mereke L.B. Gorsira for critically reading and correcting the English manuscript.

References


