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Design for Collaboration

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Abstract: Online learning environments offer new opportunities for learning and over the last decade or so a variety of online learning environments have been developed by researchers to facilitate collaborative learning among students. In this paper we will present a case study of a successful collaborative learning design. This involves a near synchronous online seminar where students work in small groups to produce a report that examines media coverage of controversial science, using archives of television news reports. We will analyze the activity's task design features by employing a framework of collaboration enabling design approach proposed by Kirschner et al (2004). We will start with an analysis of the collaborative processes and interaction among participants in this online activity. Then we will examine the features of the task used in this learning environment with respect to the interaction design ideas proposed by Kirschner et al. They suggest that the use of appropriately designed and implemented educational, social and technological affordances is the foundation for stimulating, motivating and maintaining collaboration among learners. We use the framework to identify factors contributing to the success of the activity.

Keywords: Collaborative learning, Computer supported collaborative learning, CSCL, collaboration design, task design

Introduction

Research in the field of computer supported collaborative learning (CSCL) over the past twenty years has been driven by two factors: a growing understanding of the benefits of collaborative learning and the development of the communication capabilities of computers. CSCL is based on the idea that the development of new software and applications bring learners together and that it can offer creative activities of intellectual exploration and social interaction (Stahl, Koschmann and Suthers, 2006). Computer supported collaborative learning environments can enhance learning by providing shared workspaces where learners can work together on authentic problems. This is valid for all levels of education but requires the careful design of the learning environment for group interaction and the provision of scaffolding, leadership, and support by

the instructor (Pea, 2004; Strijbos, Kirschner and Martens, 2004).

As the above studies indicate just providing an environment with a social interaction setting does not guarantee that learners will interact with each other or experience deeper learning and construction of new knowledge. Some studies have demonstrated low level, short discussions and limited sharing of knowledge in different online learning environments. (Arvaja et al, 2003; Hara et al, 2000; Lipponen 2001) In addition to the lack of nonverbal cues, these environments lack immediate feedback and this may prevent participants establishing social interaction. There is a need to pay more attention to interactive processes and a better understanding of the relationship between social interaction and knowledge construction.

Researchers such as Light and Littleton (1999) and Crook (1994) discuss the ways in which using technology impacts the learning situation in collaborative settings. To be able to design technology to support collaborative learning and knowledge building we need to gain a better understanding of how small groups of learners construct shared meaning using various artifacts and media (Stahl et al, 2006). There is a body of research that is termed the systemic approach (Ludvigsen and Morch, 2010) that "concerns the generation of models of how specific features of technological systems support or constrain collaboration, reasoning, knowledge representation and structure of discourse" (Dillenbourg, 1999) and to what extent these features will enhance students' capacities to solve problems in different domains (Arnseth and Ludvigsen, 2006)." For example Fischer and Mandl (2005) used different types of tasks and technological (computer supported) scripts to organize turn taking alongside social scripts (such as role distribution) and found that scripts were useful for scaffolding learning and knowledge construction in certain domains. One of the most influential CSCL approaches in this area is Scardamalia and Bereiter's (2006) knowledge building approach which is a model for distributed collaborative learning based on how professional scientists work to solve problems.

Hmelo-Silver (2003) argues that new learning environments require an innovative approach to explore the ways in which they can enhance computer supported collaborative learning (CSCL). Researchers carried out many experimental studies that may help us to understand the potential benefits of CSCL and to determine the mechanisms of collaboration in these learning environments. However, Scanlon (2011) suggests that these experimental studies are often of little use in terms of the design of educational guidelines for the development of CSCL activities. She proposes the development of a multi-faceted approach to investigating computer supported collaborative learning. It involves investigating collaborative learning from a range of perspectives: the learners, the teacher or instructor and the researchers (Scanlon, 2011).

In addition, rather than considering only the outcomes of a learning experience or a snapshot of the activity, where possible, she suggests that researchers should develop a detailed picture of how individuals in a group situation interact and how those interactions develop over time (Scanlon, 2011).

Understanding how collaborative groups construct knowledge through joint activity requires investigating under what conditions collaboration is successful and when intended learning outcomes are achieved. This is by no means an easy task. For example, collaborative learning involves individuals as group members but is also concerned with activities such as the negotiation and sharing of meanings that are realized interactively by the group members. Kirshner et al (2004) argues that in a collaborative learning environment individual and group level variables mediate the learning process and therefore predefining the conditions for learning is almost impossible. These concerns require that we

study learners not only as individuals but focus on what is taking place in their interactions.

Adding technological features in a collaborative environment makes it even more difficult to specify the interactions between members of the group working together. It is our experience that introducing technology into a setting can have both predictable and unpredictable effects. For example ideas that are valid for face-to-face environments may not work for online collaborative environments even if they are synchronous, have chat, shared tools, etc. and the tools might be used in unexpected ways (e.g. participants using only the first option of a sentence opener in an online discussion tool and ignoring the meaning of that opener). This is because using technologically mediated collaboration changes the nature of the activity in ways we can not necessarily predict. To explore this, researchers conducted work looking at situations where members of a problem solving team are physically separated and then connected using computers and visual communications technologies to work collaboratively (Scanlon 2011). These studies helped to further understand the particular ways workspaces could be designed to enhance collaboration. In this paper we will consider the educational and social aspects of a collaborative learning environment and what this implies for the design of collaborative learning enabled by technology.

Background to the study

The complexity of the process of designing online collaborative activities that will actually result in collaborative learning is an issue that educational researchers need to continue to work on. Many educational researchers accept that the basic principles of the socio-cultural approach are important for the design of learning environments, but "the adoption of these principles have been hampered by a complex chain of elaborations before the principles can be used for developing specific tools" (Ludvigsen and Morch, 2010, p.93). As suggested by Dillenbourg, Jarvela and Fischer (2009) finding a route through to effective use of methods and tools has proved resistant to solution, particularly in technology enhanced learning environments.

According to Kirschner et al (2004) there are two problems with research into and the design of computer supported collaborative learning (CSCL) environments: "a tendency to focus on surface characteristics" and "to apply traditional classroom ideas and pedagogy in non-contiguous collaborative learning environments" (p. 59). In order to overcome these difficulties they consider how to design CSCL environments by focusing on educational, social and technical affordances and consider educational affordances first. They describe educational affordances as the relationships between the learner and the environment that define if and how learning will take place. Consequently, educational affordances are the features of the learning environment that support the learning needs of the students as they become apparent. Social affordances on the other hand facilitate and encourage interaction and collaborative learning. In addition online environments require that we consider technical affordances. Kirshner et al, (2004) describe technical affordances as those that "mediate the social and educational contexts such that their properties induce and invite specific learning behaviors" (p. 50).

One of the great challenges of learning design in computer supported collaborative learning (CSCL) is to design effective interactive learning scenarios. The task is one of the critical elements that can help to operationalise educational affordances:

Since most educational design for skills or competence-based education (e.g., problem based, project-centered, case-based, etc.) tends to focus on the task, we will focus more specifically on operationalizing educational affordances through a critical element that affords the interaction between students: the

task. Task ownership, task character, and task control are defining factors in the educational affording of environments. (Kirshner et al, 2004, p.54)

According to Kirschner et al (2004) task ownership is related to individual accountability and positive interdependence. When students are individually accountable for their work, they will all invest in the group performance. In addition if they are dependent on each other and support and motivate each other to reach group goals, this creates positive interdependence. In other words, individual accountability, positive interdependence, and subsequent promotive interaction creates a learning environment where participants are encouraged to work together towards a common goal, contributing more or less equally towards the completion of the task. The presence of particular roles for participants in the collaborative learning environment is also a factor contributing to group cohesion and responsibility (Forsyth, 1999), and in helping to create individual accountability and positive interdependence.

Task character is related to the extent to which the task is close to real life and how much it is designed so that it is divided into non-trivial authentic parts. The last of these defining factors in the educational affording of environments, task control is, in essence similar to learner control. This means that the learner has the opportunity to select what information to access as well as how to sequence the information in a manner that is meaningful for him or her. This way, the learner is given control over his or her own instruction and can control the path, pace and contingencies of instruction.

A better understanding of how computer supported collaborative learning works is relevant for both formal and informal learning and in the context of learning and social media. If we consider that many higher education institutions use social media, but far less for teaching compared to other activities such as admissions, communications (see www.educause.edu/ero/article/overcoming-hurdles-social-media-education) it can be argued that knowing how to design collaborative tasks in social networking sites would be very useful for teachers and instructors. Researchers are already exploring links between social media and education (Elavsky, Mislan and Elavsky, 2011) and documenting potential of social networking (e.g. microblogging) for giving feedback (Junco, Heiberger and Loken, 2010). Most recently an area to which findings on effective pedagogy of computer supported collaborative learning are important is that of Massive Open Online Courses (MOOCs) (Masters, 2011). As argued by Masters (2011) learner participation is crucial in these learning environments and a description of pedagogical principles that can be followed in online collaborative environments may prove beneficial for the design of MOOCs. The importance of learner interaction is also emphasized by Dillenbourg, Jarvela and Fischer (2009): "collaboration per se does not produce learning outcomes; its results depend upon the extent to which groups actually engage in productive interactions" (p. 4).

In The New York Times article Instruction for Masses Knocks Down Campus Walls, Lewin (2012) stated that "in the past few months hundreds of thousands of motivated students around the world who lack access to elite universities have been embracing them [MOOCs] as a path toward sophisticated skills and high-paying jobs, without paying tuition or collecting a college degree." According to the same article the current MOOCS are more technically oriented than earlier ones and have computer-graded assignment and exams. The opportunities for social interaction are plenty. For example Artificial Intelligence course of Stanford, taught by Sebastian Thrun and Peter Norvig included virtual office hours and online discussion forums for students to ask and answer questions and peer assess the value of these contributions.

In this paper we will examine an online task, a collaborative activity set as part

of Master's level study. We use methods such as content analysis and interaction analysis to determine the success of the collaborative activity. We then employ Kirschner et al framework for design of online environments to see whether this helps us determine what features are responsible for this success.

Case Study

Course and the participants

The case study presented in this paper takes place at a distance learning institution and students are studying for an MSc in Science and Society. The course is about science communication, has normally around 90 students registered a year, lasts 32 weeks and most of the tuition is conducted electronically using a text based asynchronous conferencing system. The course web site provides access to a number of digital tools including forums, wikis, news feeds, etc. Students are expected to take part in moderated and informal online forums. These include administrative ones such as 'News' forum, 'Café' forum for informal discussions among students, 'Course forum' covering issues emerging from course materials and also smaller group discussion forums for planning, assessment and teaching-related discussions. In addition 3 limited duration online seminar forums provide task-based discussions on particular topics related to course materials (one of which investigated in this paper). The course reviews the variety of ways in which scientific ideas are communicated to the public by formal and informal means and the relationship between scientists and the media is discussed. Information and communication technologies are used to allow students to engage in discussions and access the web for information. The course aims to help students develop skills in communicating scientific ideas to a variety of audiences, to develop skills in the study of communication and to consider ways in which the contemporary mass media influence the communication of scientific information and understanding. In the course online seminars are the main means of communication between students and their teachers and their only opportunity for collaborative work. These online seminars are mainly asynchronous conferences lasting from one day to 2-3 weeks. The online seminar investigated in this study is a day-long one and the communication is near synchronous.

The task that was set required the students to produce analyses of media archives on contested science topics during a day-long activity where they worked in small groups of 4-8 participants. In the online seminar that we examined there were nine students as sometimes groups need to be re-organized to make sure every group had comparable numbers. After students individually examined the archive of newspaper articles and videos (provided in course materials) and performed a content analysis of this media archive, they sent an opening statement (about 250 words) to the online seminar. They addressed the following questions in their opening statements:

1. What is the nature of science portrayed by the different announcements?
2. How does this impact on the coverage and the development of the story?
3. Does this change over time?
4. What is the target audience for the video material?

All nine students sent their opening statements and they addressed the above questions. These initial statements provided a starting point for discussion as students commented on each other's initial statements and mentioned the points with which they agreed and disagreed. The exchanges were mainly complementary as students covered many aspects and discussed different scientific controversies. Students were asked to exchange ideas, debate findings and produce a collective group report at the end of the day. As mentioned before one of the aims of the course was to help students develop skills to consider

ways in which the contemporary mass media influence the communication of scientific information and understanding. As we will see below in the collaborative processes analysis, students collaboratively considered media influence on scientific information and understanding and both the task set and the resourcing of the collaborative experience led to extensive discussion and a product (final collaborative report) that could be evaluated, which helps to assess learning (Crook 1994).

In addition, this activity is only one of the several activities similarly designed to provide collaborative studying experience for the duration of the course. These activities are carefully selected in areas that would be interest to students, structured to provide a collaborative environment and students are presented these tasks during the course at relevant points.

Methodology

Collaborative Processes

In the first part of our analyses we explored collaborative actions taking place in the one-day online seminar dealing with portrayal of science in media. We performed a content analysis of all the contributions in the online seminar. We employed a classification system developed in our earlier work (Jones, Scanlon and Blake, 2000; Blake and Scanlon, 2012) and validated and extended it using the rating scheme by Meier et al for assessing the quality of computer supported collaboration processes (see Meier et al 2007 and Rummel et al 2011). In these analyses we took the whole message as the unit of analysis as suggested by Rourke et al (2001) as it combines the flexibility of the thematic unit with the reliable identification of attributes of a syntactical unit. The categories of collaborative processes used in the present study are as follows:

Joint knowledge building: presenting and defending a position by giving one or more rationale or justifying the opinion by explaining it (comparable to Meier's communication/sustaining mutual understanding category)

Asking questions or dialogue extension prompts: asking questions, sometimes not actually to get an answer but to prompt fellow students to think/contribute on a certain subject (comparable to Meier's communication/sustaining mutual understanding category)

Supporting the argument with a reference and or an example: giving an example or providing a reference to clarify the topic under discussion (comparable to Meier's communication/sustaining mutual understanding category)

Acknowledging/replying/ referring to another message: referring to/extending on ideas in a fellow students contribution (reciprocal/cooperative orientation in Meier's classification; 'interpersonal relationship' category in Meier's extended rating scheme)

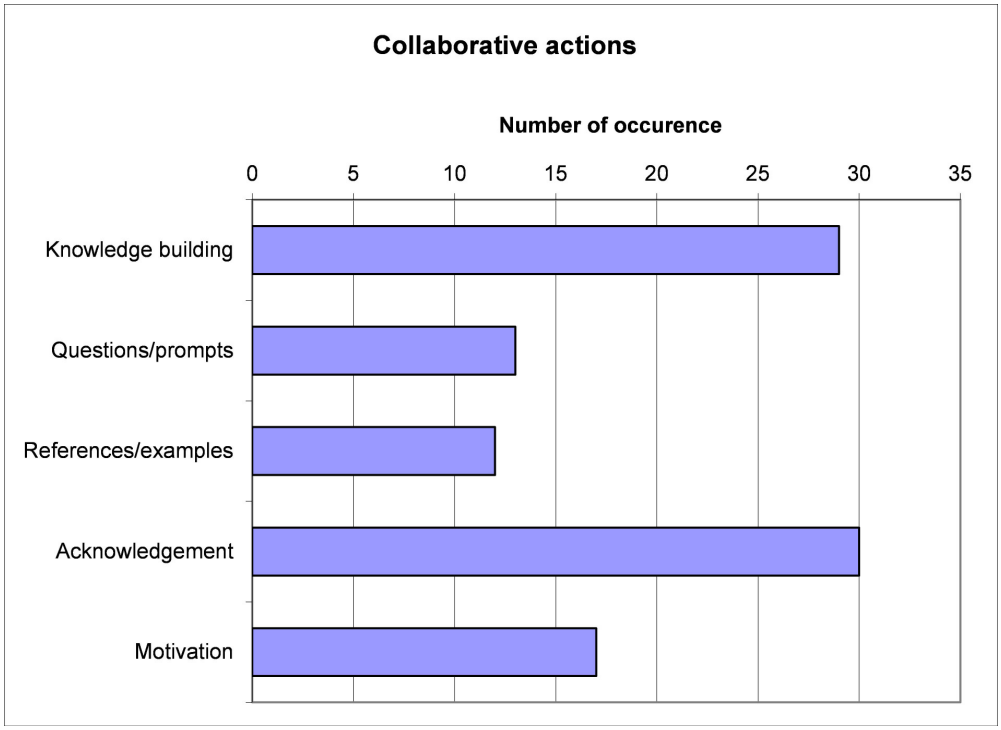
Motivation and commitment: contributions referring to participants' individual motivation and commitment to the task (taken from Meier's extended rating scheme; not used by us in earlier work).

Instructions/information: contributions that are related to running of the collaborative activity ('coordination' category in Meier's extended rating scheme)

Nine students took part in this seminar and most students sent 5-12 messages. Altogether the students sent 117 messages to the online seminar and the total number of words was 12950. Two students only sent a couple of messages at the beginning because they could not attend all day. As the seminar lasted only

a day (from 11am- 4 pm) there were 52 Instructions /information category messages (mainly from the teacher) that were necessary to co-ordinate the activity. We excluded these messages from the analysis in order to focus on joint knowledge building messages although these Instructions/information messages also included indicators of joint activity (e.g. deciding time tables for the activity). The remaining 62 messages were all student contributions to group report discussing the portrayal of science in media. Students mainly focused on the news related to the Genetically Modified Organisms (GMO) debate in the UK. The distribution of student contributions to the categories of collaborative actions is presented in Figure 1 below. These categories are not mutually exclusive, i.e. a message could be marked with any of the categories above, so the total number shown in the chart in Figure 1 is higher than 62.

Figure 1. The distribution of collaborative actions



The biggest categories are collaborative processes of 'joint knowledge building' and 'acknowledging/replying/referring to another message'. The messages in the co-ordination category are not included in this analysis. One interesting aspect of this analysis is the presence of personal and motivational references in so many of the messages, indicating participants' willingness in sharing their personal situations and motivational commitment to the task.

The student contribution examples below indicate that students demonstrated an enhanced understanding of the features of media reporting rather than an enhanced appreciation of the science being studied. The quotes reproduced below indicate how students brought their experiences and knowledge to the discussion and collaborated with fellow students to jointly answer questions posed at the beginning of the day. We also marked these contributions as examples of the above categories to show how the content analysis was carried out. Three examples of a student message indicating the categories to which it was assigned are presented below:

Hi I know this is going to be posted before the stated time but I might as well do this when I remember!

(Instructions/information)

After watching the bulletins of the GMO, it was very interesting to see how the story progressed both in the mainstream media and in the way (finally) how the horizon program dealt with the subject. Initially the news in extract 1 the feel is that GM foods are being looked into for their benefits to farming and to those who live in countries who need food, but at the end of the extract there is the interview with Arpad Pusztai and the whole question of "are GM foods safe" is out into question and then the results of Arpad's research are given as a warning to not use GM foods.

(***Joint knowledge building***)

(message from Lenny - Names changed)

I very much appreciated Lenny's detailed review of the various extracts.

(***Acknowledging/replying referring to another message***)

I agree that the final extracts from the Horizon programme appear to be sensationalism. This was very much the way Horizon approached science presentation at this time, which can be traced to a deal they made with the US's Discovery Channel in 1998 (BBC, 2002).

(***Supporting the argument with a reference and or an example***)

Dr Pusztai justifies going to the press in advance of peer-reviewed publication on the grounds of personal conscience and the need to raise the issue sooner rather than latter. His actions and the subsequent press coverage certainly put the issue into the public spotlight. Would it have had the same coverage if he had followed the traditional route of awaiting publication? Personally I doubt it.

(***Asking questions or dialogue extension prompts***)

(message from Sylvia - Names changed)

I'd also like to thank everyone for participating - this has given me quite a lot to think about.

*(**Motivation and commitment**)*

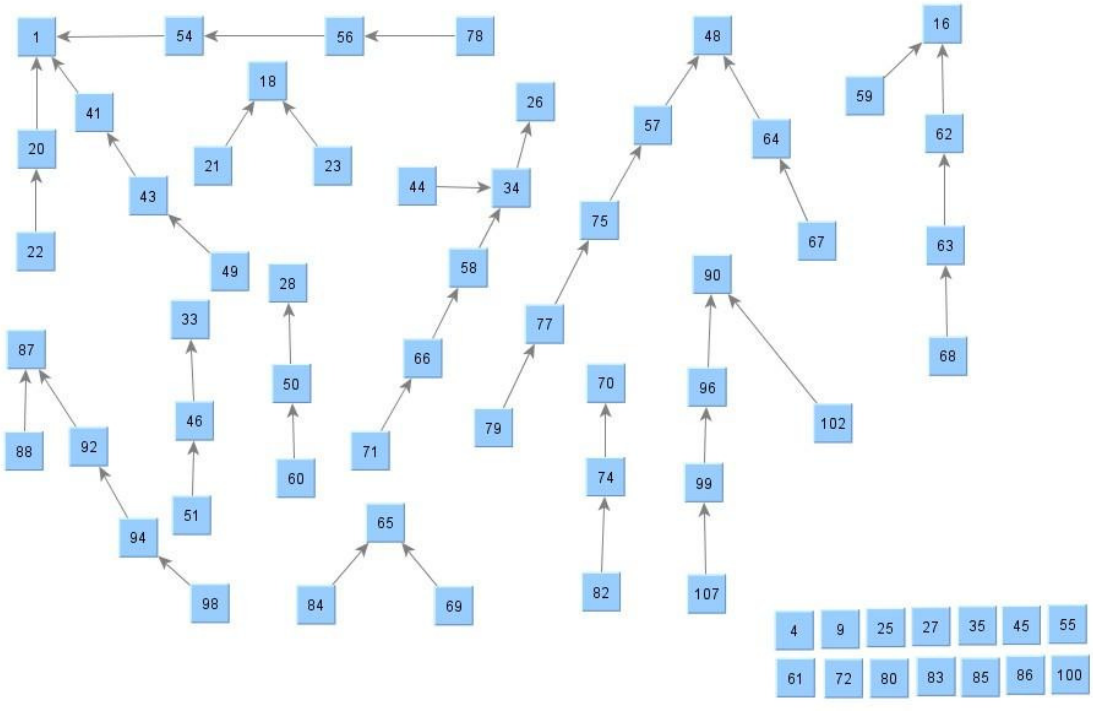
(message from Vicky-names changed)

Interaction Analysis

Interactions among participants were our next focus for the study. For this purpose a pictorial representation of the conference was prepared using social network analysis methods. Social network analysis allows identification of "patterns of relationship between people who are connected, and analysis of the structure of these patterns by tracing the flow of information and/or other resources that are exchanged among them" (de Laat, 2006 p.86).

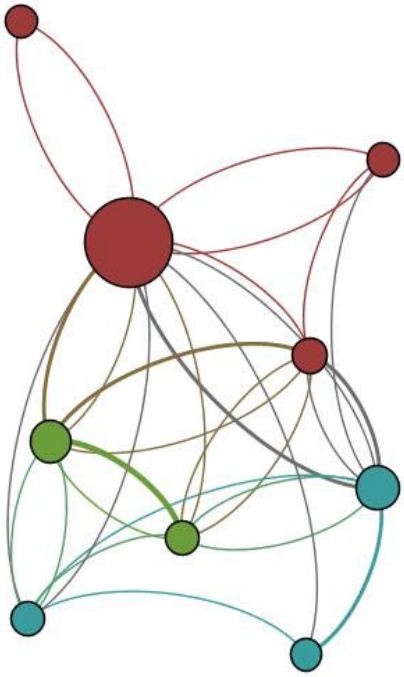
The interaction map of the conference is presented in Figure 2. In this map the nodes represent the messages sent to the online seminar. The map shows messages referring to an earlier message (indicated by a directed arrow) by commenting, quoting, replying or adding to that message. All messages are numbered according to the order in which they were sent to the online seminar (different individuals and the summary content of the messages are not shown in this map as it is difficult to see too many details). The map shows that only 14 of 62 messages were not linked to any other message in the discussion. Some of these are the opening statements and the comments sent towards the end of the discussion. It is also possible to see different topics of discussion forming clusters, some with more contributions than the others. For example the cluster formed by messages 26, 34, 44, 58, 66, 71 is about underrepresentation of public and institutions such as Greenpeace in the coverage of genetically modified foods and governments and multinationals dictating what is best for the public. Similarly messages 16, 59, 62, 63, 68 are about Dr Pusztai's work on genetically modified organisms (GMO) and uncertainty regarding GMO research.

Figure 2. Interaction map for the online seminar.



When we put this data in to Gephi (an open source software for visualizing and analyzing large network graphs http://gephi.org) we obtain the pattern of interaction among the students presented in Figure 3.

Figure 3. Interaction Patterns in the whole discussion.



This new graph shows the influential students (nodes) in the discussion, indicated by the size of the nodes and the exchanges between them as lines between the nodes (thickness indicates more interaction). It is also possible to measure the centrality (how well a node is connected) of individual students in this analysis and this can be different from number of messages sent by them.

Discussion

The analysis of collaborative processes and the interaction between participants shown here indicate that students were fully engaged in the discussion related to the coverage of Genetically Modified Organisms in the media. They answered the questions posed at the beginning and produced the collaborative report at the end of the activity. Students carried out this activity by jointly constructing their knowledge during the course of the day, explaining the reasons for the ideas they put forward, acknowledging and expanding contributions from fellow students.

Students' contributions to the online seminar contained many references to different resources including course materials and own personal observations of science in media such as references to BBC programmes or policy documents. These messages were marked in the category 'References/examples'. Students developed their ideas based on one another's contributions/suggestions and it is clear that contributions are contingent upon what the other students contribute as shown in the above quote from Sylvia to Lenny. Students drew on each other's' prior knowledge and cultural models. These references to prior knowledge and cultural contexts facilitate students' progress and understanding of the task in hand. The patterns of activity and the content analyses suggest this is a potentially successful CSCL design (for the successful activity was recognized by the course team who used this activity for five successive annual presentations of the course).

Design features of the task

There are several points in the design of the task that require careful consideration because they contribute to the success of the activity. These are summarised in Table 1. The near synchronous nature of the activity facilitates both task specific and informal interaction and increases the productivity of the group. In a way it "bridges the gap imposed by asynchronicity" (Kirschner et al, 2004, p.59). This is also related to social affordance (one of the three affordances that is important for the design of CSCL environments: educational, social and technological) which is also possible to design into the environment by including tools such as group awareness widgets that explicitly embed social functionality.

The design of the task in this activity requires students to start the discussion with a contribution presenting their position with regards to initial questions. This prompts students to comment on each other's contributions and this in turn encourages them to engage in social interaction.

Students shape the discussion themselves, although the main area of the task is decided by the teacher, the task itself is flexible and uses real life news items from media. By letting students decide what to discuss the activity makes students realise that it is their responsibility to come up with ideas (task ownership) and they decide what to discuss and how to go about it (task control). The questions posed at the beginning of the activity help students tackle the whole task in smaller segments, therefore "stimulate the learners to describe, explain, predict, argue, critique, explicate and define" (Kirschner et al, 2004, p. 55).

Table 1. Design features of the task (adapted from Kirschner et al, 2004).

	Design features of the task
Task ownership	• Students are not assessed as a group. The whole online seminar will help them in their individual assignments. • They have divided roles for collating the report and addressing the different parts of the task.
Task character	• The task is arranged around a real life media archive • It is segmented into smaller chunks by introducing initial questions and opening statements. • It is designed to be completed in one day after initial individual work
Task control	• Students decide what scientific event they will focus on (e.g. GMO) • The discussion is completely under the control of the students.

The group does assign a reporter to compile the final report so there is a role assignment aspect. Forsyth (1999) argues that the sense of belonging in a group is essential for team formation, and Kirschner et al. (2004) argue that functional roles can provide group cohesion, a sense of responsibility and interaction all leading to social affordance.

The group task (production of the collective report) is not assessed and the activity remains optional. However the group's task is linked to individual assessment task and students are encouraged to make reference to peer contributions in their individual assessment. By completing this task, students can combine their efforts to cover a bigger portion of the work than they could achieve on their own and in turn this may help their completion of the course assignment (leading to positive interdependence and promotive interaction).

Conclusions

The use of content analysis in this study has been shown to be beneficial as a way of evaluating the educational effectiveness of an online discussion. The content analysis of the online seminar provided us with an understanding of what issues students were talking about, how they were using the course materials to further their learning and the extent to which their activities were collaborative. This also provided evidence of learning processes occurring in the online seminars in this graduate course. We were able to label messages that contribute to group task by providing knowledge, references, examples, questions and explanations.

In addition to these analyses we used Kirschner et al (2004) framework for designing electronic environments focusing on educational and social affordance of CSCL systems and critically considered the nature of task design to separate the factors that may have contributed to the success of the online seminar.

Our analyses also showed that in order to understand collaborative learning we need to consider contextual aspects of the student discussion and see how tools/objects mediate learning in an environment where students' social, personal and cultural contexts are interwoven with the task in hand. In addition, our initial analyses in this study have shown that the reciprocal relationship among participants in an online discussion environment could be an important factor in enhancing the efficiency of joint knowledge building and other collaborative processes as shown by the high number of messages containing motivational and personal references. This approach to analysis of collaborative processes in web-based forums can be further enriched by additional data in the form of interviews or diaries so that interpretations are not only dependent on researcher's perspective.

In addition to content and interaction and task analysis, the context of the collaboration should also be taken into consideration in order to understand how different aspects of a situation mediate participants' learning. Guided by the discourse analysis work of Gee and Green (1998) and the interaction analysis work by Mercer et al (2009) this approach involves identifying objects and artifacts that are used during interaction such as referring to course materials or other resources and participants' cultural, personal and social experiences, prior knowledge and assumptions. Further analyses of these contextual aspects of the collaboration could be interesting but these are beyond the scope of this paper and we will pursue them in future work. We are interested in combining different aspects of collaborative learning research in a project that aims to explore variables that effect collaborative learning in an experimental study and explore innovative design possibilities at the same time. This may help to refine methodologies and approaches to analyzing interaction and collaborative learning in a group rather than focusing on individual learning.

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