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Local and Distributed Interaction in a Collaborative Knowledge Building Scenario

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Abstract. The structure and organization of a learning environment has implications for how students organize their collaborative interactions and learning activities. Investigating how students understand and utilize the collaborative conditions in a learning environment is thus a key issue to obtain insight into how to improve the design of such environments. In this paper we identify how collaborative knowledge building is produced in distributed and co-located interactions between students and discuss how this is related to the design of the learning environment.

Keywords: Interaction analysis, distributed collaborative learning, inquiry learning, knowledge building.

INTRODUCTION

In the DoCTA project (Design and Use of Collaborative Telelearning Artefacts) the focus is on the design and use of technological artefacts to support collaborative learning in distributed settings (Wasson, Guribye, & Mørch, 2000; Wasson & Ludvigsen, 2003). One of the most important goals of DoCTA is to develop knowledge about how to create a good learning environment for students with the help of information and communication technologies (ICT). A central aspect of such creation is how students work, both individually and collaboratively in a discipline. As part of DoCTA we have organised a number of different field trials and design experiments where students have been working together in different virtual learning environments. In this paper we will report from our last scenario, *genetikk*, where we investigated how the pedagogical design of an ICT-mediated collaborative learning environment enables students to learn complex concepts and how they can go about discussing these concepts in the broader learning community[1].

In this paper we focus on the structure and organization of a learning environment and how students organize their collaborative interactions and learning activities within this environment. Structure and organization here relate to notions of scripts and semi-structured communication interfaces (Dillenbourg, 2002). We believe that detailed investigations of how students actually collaborate and struggle to enhance their understanding are a key issue in order to obtain insight into how to improve the design of such learning environments.

We take a sociocultural perspective on learning and use Interaction Analysis (Jordan & Henderson, 1995) as our methodological framework. By studying the interaction between collaborating students in detail from an IA perspective, we can uncover how the students make their evolving understanding visible to each other (Stahl, 2002) and how the artifacts that they use are an integral part of this process. Small groups of students have been video recorded while collaborating in front of the computer screen. These recordings, combined with ethnographic methods like participant observation and interviews, give a detailed account of how the groups organised their work (Rysjedal, forthcoming). The paper begins with a description of the *genetikk* scenario, which forms the basis of this study. Then one analysis from Rysjedal (forthcoming) is presented. The paper concludes with a general discussion of the findings and how these are related to design of the scenario.

THE GENETIKK SCENARIO

Design experiments (Brown, 1992) can be seen as intervention in educational practice since the researchers, in collaboration with teachers, try to change the way student's work (Ludvigsen & Mørch, 2003). In our design

[1] There have been many empirical studies carried out on the *genetikk* scenario (e.g., Arnseth, 2004; Arnseth, Ludvigsen, Guribye, & Wasson, 2002; Brændshøy, 2003; Bråten, 2002; Kolstø, 2003; Ludvigsen & Mørch, 2003; Roness, 2003)

experiment we intervened in grade 10 natural science education by introducing an ICT-mediated collaborative learning scenario in gene technology, *genetikk*. In *genetikk* a cross curriculum scenario of natural science, religion & ethics (KRL) and Norwegian was developed collaboratively between the researchers and teachers and the learning goals related to the biological, ethical and societal aspects of gene technology. The pedagogical approach was progressive inquiry learning (Muukkonen, Hakkarainen, & Lakkala, 1999) and a web-based groupware system, FLE3, that supports this model was used as the main learning technology. Students in two classes collaborated in both co-located (within groups in a class) and distributed (between groups in two different Norwegian cities) settings to share and discuss ideas and arguments around scientific and ethical questions related to gene technology. In this section we elaborate on the design rationale behind the scenario by detailing the pedagogical approach and the didactic design and then introduce the technological environment and describe the deployment of the scenario.

Pedagogical Approach and Didactic design

Progressive inquiry learning is an approach to collaborative knowledge building (Scardamalia & Bereiter, 1996) where students engage in an research-like process to gain understanding of a knowledge domain by generating their own problems, proposing tentative hypotheses and searching for deepening knowledge collaboratively. As a starting point for progressive inquiry learning, a context and the goal for a study project needs to be established in order for the students to understand why the topic is worthwhile investigating. Then the instructor or the students present their research problems/questions that define the directions where the inquiry goes. As the inquiry cycle proceeds, more refined questions will emerge. Focusing on the research problems, the students construct their working theories, hypotheses, and interpretations based on their background knowledge and their research. Then the students assess strengths and weaknesses of different explanations and identify contradictions and gaps of knowledge. To refine the explanation, fill in the knowledge gaps and provide deeper explanation, the students have to do research and acquire new information on the related topics, which may result in new working theories. In so doing, the students move step by step toward building up knowledge to answer the initial question. The role of the teachers is to be a facilitator for the students. The teachers can stimulate self-regulation by the students by giving comments and advice, both within the classroom and in the online environment

The didactic design was inspired by the progressive inquiry approach to knowledge building and has elements of a script as defined by Dillenbourg (2002). Animated by a trigger video[2] to set the context and supported by the structure and resources in the learning environment, the students themselves will identify problems on which to work, decide where they wanted to search for information, participate in inquiry learning cycles and create newspaper articles. We developed a set of activities with instructions which included assignments related to the inquiry learning cycle (e.g., generate scientific and ethical questions about gene technology; engage in inquiry about selected questions, compose scientific explanations, etc.) and products related to expressions of what they have learned (scientific and ethical questions, science questions for use on a test, write individual and collaborate texts on opinions about an argument or a discussion about a scientific or ethical question to be published in the national school newspaper).

The digital learning environment

A web portal was designed in order to provide the students with a shared online space. From this portal the students had access to various learning resources, collaboration tools, and a tool for Internet publishing called Skoleavisa (an online newspaper generator available for all schools in Norway). Among the learning resources they could find an online text book (previously written by 2 of the DoCTA researchers), a Norwegian encyclopaedia, animations, a newspaper database called Atekst and some selected links to external resources on the Internet.

The main tool for collaboration was Future Learning Environment 3, FLE3 (http://fle3.uiah.fi). FLE3[3] is designed to support collaborative knowledge building and progressive inquiry learning (Muukkonen et al., 1999). To support the collaborative inquiry learning process, FLE3 provides several modules, such as a WebTop, a Knowledge Building module, and an Administration module. The Web Top provides each group with a place where they can store and share digital material with other groups. An automatically generated message that tells what has happened since the last time they visited FLE3 also appears here. The Knowledge Building module is considered to be the scaffolding module for progressive inquiry and it can be seen as what Dillenbourg (2002)

2 We edited a Norwegian National Broadcasting Corporation (NRK) documentary on gene technology to 4 5-minute segments, each presenting a different theme within genetic technology.

3 FLE3 was developed by the Learning Environments for Progressive Inquiry Research Group at the UIAH Media Lab, University of Art and Design Helsinki in cooperation with the Centre for Research on Networked Learning and Knowledge Building, Department of Psychology, University of Helsinki.

calls a semi-structured communication interface. It is a shared database where the students can publish problem statements or research questions, and engage in knowledge building dialogues around these problems by posting their messages to the common workspace according to predefined categories which structure the dialogue. These categories are defined to reflect the different phases in the progressive inquiry process and included: Question, Our explanation, Scientific explanation, Summary, Comment and Process Comment. We added a digital assistant to FLE3 (Chen & Wasson, 2003) to support both the students and teachers in monitoring what happened inside FLE3 (Dragsnes, Chen, & Baggetun, 2002). All messages are visible as lists of messages which can be sorted by topic (thread), person, category and date. In addition to FLE3, a combined chat and mind mapping tool (Dragsnes, 2003) was developed and made available for the students to add support for synchronous communication.

Deployment

Genetikk took place over 31 hours during the three last weeks of September 2002, and involved two grade 10 classes, one from Bergen (24 students) and one from Oslo (27 students). Five of the 31 hours were concurrent (i.e., both classes worked on genetikk at the same time) and synchronous communication was possible. The scenario began with each class viewing the trigger video on genetic technology. Then the students brainstormed about questions related to genetic technology. This brainstorming session generated a long list of questions from the two classes, and the teachers used these questions in order to make one single list of questions with 12 scientific questions and 12 ethical questions about genetics. This list of questions was published on the web portal.

The two classes were then divided into *local groups* with 3 or 4 members, and each of the local groups in Bergen was connected to a local group in Oslo to form a *composed group*. The scenario had two phases, and in the first phase the composed groups discussed the list of questions and decided on three scientific questions to work on. These questions were posted as problem-statements in FLE3 before they started to search for and discuss information around their questions. Whenever they found something relevant, they could post it as a note in the Knowledge Building module in FLE3. After having explored the questions for about a week the students should use the information they had gathered in order to write at least three different articles about genetics. These articles were published in Skoleavisa, the online newspaper generator.

In the second phase of the scenario the focus was turned to the ethical aspects of gene technology. The list of questions was revisited, and this time the composed groups should decide on 3 ethical questions on which they wanted to work. The same inquiry process was repeated in this phase, with about one week of inquiry of questions before publishing articles in Skoleavisa. It was believed that focusing on scientific aspects before they turned to the ethical aspects would increase the students' abilities to argue on their ethical viewpoints. By the end of the project 60 articles were published in the online newspaper and every group had contributed with articles. Some of the groups, however, produced more articles than others. One of the composed groups had published 13 articles, while another group had published 7 articles.

Research procedure

The authors participated in the didactic design, the design of the digital learning environment and in observations and data collection during the scenario deployment. In both schools, the field activities were observed[4] by at least 1 researcher and one person from the technical staff. In this paper we use empirical data collected from following a distributed group we refer to as Composed A. Composed A comprises one local group from Bergen (Bergen A) and one local group from Oslo (Oslo A). Bergen A and Oslo A were video recorded while they were working on *genetikk*. These recordings, synchronized with logs of their computer activity and a screencam of their interactions in the environment, give a rather detailed representation of how Bergen A and Oslo A were working and interacting. A content log of all the recordings gives an overview of how the group organised their work, and episodes that were considered particularly interesting have been transcribed according to transcription conventions described in Silvermann (1997) and translated from Norwegian to English. Furthermore, all their postings in FLE3 are stored on CD-rom and as printouts and group interviews were also carried out after the project period (see Roness, 2003). Articles and inquiries within other groups have only been briefly analysed in order to make sure that the work within Composed A is not noticeable different from the work within other groups.

[4] The authors of this paper observed the students in Bergen and had daily contact with researchers observing the students in Oslo.

DISTRIBUTED AND LOCAL KNOWLEDGE BUILDING

Investigation of the notes in the Knowledge Building Module of FLE3 revealed that apart from the negotiations of which questions to select for inquiry, there had been minimal interaction between the local groups. Composed A collaboratively selected three Scientific and three Ethical questions on which they wanted to work (they were to work on each set of questions for one week). For each of the six questions the students created a separate thread in the Knowledge Building module where they were supposed to engage in collaborative inquiry of the questions. They were to post their own explanations, post scientific explanations they found in different resources, comment on each other entries, follow up with new questions, etc. As table 1 shows, there were only two threads with more than four notes. Thus, the students did not use the Knowledge Building module and the categories as intended in order to support the progressive inquiry model. For more detailed analyses about the students' use of the categories in FLE3, see Ludvigsen & Mørch (2003) and Arnseth (2004).

Table 1: Number of notes posted within each category in the Knowledge Building module of FLE3

	Scientific phase			**Ethical phase**		
Category Thread	**SQ 1**	**SQ 2**	**SQ 3**	**EQ 4**	**EQ 5**	**EQ 6**
Question	2	3	2	1	1	1
Our explanation		1	1	3	3	3
Scientific explanation	1	2				
Comment						
Process-comment	1	1	3			
Summary		2	3			
Total	4	9	9	4	4	4

Careful examination of the newspaper articles, however, indicated that despite the limited use of the Knowledge Building module the questions had been thoroughly investigated by the students (Rysjedal, forthcoming). Examinations of how the students actually collaborated to solve their tasks revealed that it was primarily within the face-to-face interactions going on in front of the computer screen that we could find evidence of students struggling to enhance their conceptual understanding.

The extract below is from an episode where the two girls, Gro and Liv, are investigating the question "Can all kinds of food be genetically modified?". They have decided that in order to be able to answer this question they first have to find out what gene modification means. Gro is searching for information about this on the Internet while Liv is reading in an encyclopaedia lying in her lap. Liv finds information in the encyclopaedia that she thinks explains gene modification, and tries to get Gro's attention by asking if she understands gene modification.

Extract 1

1. Liv: Yes, I think I understand it.
2. (8.0)
3. Liv: Do you understand it?
4. Gro: What then?
5. Liv: This.
6. Gro: Yes.
7. Liv: What gene modification is?
8. Gro: Yes- No.
9. Liv: What is it then?
10. Gro: Well it is- No.
11. Liv: Try then.
12. (1.5)
13. Gro: What gene modification is? Well it is (.) to replace, isn't it. (2.5) No I don't understand it at all.
14. Liv: It is modification of an organism's genetic composition by the use of gene and cell technology. ((Liv is
15. reading from an encyclopedia))
16. Gro: So, what are they doing, then?
17. Liv: Then they are changing the genetic material.
18. Gro: So that (.) No, I don't understand it.
19. ((Liv is reading silently in the encyclopaedia.))
20. (7.0)
21. Liv: Well, that's what they are doing. (1.5). Well, but that has- How- But what- What connection can that have
22. with food. (1.0) Then it has to be meat.
23. Gro: It has to be meat, doesn't it?

24. Liv: Well, but when you talked about rice.
25. (2.0)
26. Gro: Ehh. Then we just have to read that rice thing properly.

This extract demonstrates how Liv encourages Gro to try to explain her understanding of what gene modification means (see lines 1-11). Gro seems to have some ideas about what this means, but she has trouble articulating them and concludes that she does not understand it at all (line 13). Liv reads the explanation from the encyclopaedia, but Gro maintains that she still does not understand it. The reason is that the explanation Liv read did not explain what they are doing (see line 16). She thereby argues that in order to get a better understanding of what gene modification is, they have to find out what is actually done when organisms are gene modified. In other words, she points out a direction for their further work.

Liv turns to the encyclopaedia again. After having looked in the encyclopaedia for seven seconds she questions how the explanation given there can be related to food. She further argues that if this is related to food it has to be bound to meat. Gro agrees to this argument. They thereby reveal that according to their understanding it is only animals that can be gene modified. But Liv is also critical to this assumption as she points out that they have previously come across an article about gene modified rice. Gro's answer to this critique is that they have to explore the rice article more thoroughly. In this way they identify yet another area they have to explore.

When Liv encouraged Gro to formulate her own explanation before she introduced the explanation from the encyclopaedia, she arranged for an opportunity where they could compare the two explanations and identify gaps or contradictions. They did not explicitly compare the two explanations, but they did evaluate the explanation from the encyclopaedia by pointing out that it did not explain what they are actually doing. Thus, they identify a weakness in the explanation and an area they have to explore further to provide a deeper explanation. Furthermore, they related this explanation to their initial question and concluded that according to their understanding of the explanation it had to be related to meat. But they also critically evaluate this assumption by pointing out that they have previously come across information about genetically modified rice.

The students also generated more specific questions during their investigations of their initial questions. These questions were usually related to information that was found or theories that were generated during their working process. The extract below is from an episode where Gro and Liv are editing a note on their Webtop. As they are working on this note, Gro introduces a new question about gene modified food.

Extract 2

1. Gro: Gene modified food. Is that for example like tomatoes that are huge?
2. Liv: Yes, it does not ripen that quickly. (1.0) It keeps longer.
3. (3.0)
4. Liv: Do tomatoes have genes then? ((They look at each other and smile))
5. Liv: I have not heard anything about that. Well.
6. ((Gro starts to read the text in the note again))

In line 1 Gro is asking if gene modified food can be tomatoes that are huge. Thus, she is trying to relate gene modified food to something familiar – tomatoes that are huge. Liv confirms that gene modified food can be tomatoes that are huge, but she also introduce another characteristic – that it does not ripen that quickly. That she mentioned this specific characteristic can be related to the fact that they the previous day found an article on the Internet about tomatoes that have had an extra gene inserted in order to prevent production of the enzyme that makes tomatoes ripen. However, in line 4 it is being questioned whether tomatoes really have genes. But this question is not explored any further. They just look at each other and smile, and Liv proclaims that this is not something she has heard about (line 5). After that they continue to edit the text in the note.

Even though many of the questions that were generated during their investigations were interesting and important questions they had a tendency not to be explored any further. The only question (apart from the initial questions) that they returned to several times was the question about what it really means to genetically modify food. The rest of the questions just seemed to disappear as they moved their attention to a new activity, such as editing a Note in FLE3, or reading something on the screen. Nevertheless, one can assume that the questions affected what information they considered relevant in their exploration of the numerous information sources they had available.

DISCUSSION AND CONCLUSION

In this study it was found that most of the interaction within the composed group was concerned with which questions they should choose for inquiry. When the students started to investigate the questions the interaction within the composed group was greatly reduced. Both local groups complained about lack of feedback from the

other group, and whenever the students found relevant information they saved the information on their local group's Webtop instead of posting it in the Knowledge Building module. The focus seemed to turn from a collaborative inquiry of the questions towards local production of articles that they could publish in the online newspaper. The moderate interaction between the distributed groups can partly be related to the didactical design of the scenario. Although the teachers encouraged the students to engage in inquiry learning by using the Knowledge Building module, it was primarily the articles in the newspaper that the students were made accountable for at the end of the project (Arnseth, 2004). This may suggest that assessment methods that emphasise process as well as product need to be used and perhaps it would have been better that they not know about the articles they would produce right from the beginning, but instead introduce them after the inquiry cycle.

Despite the moderate use of the Knowledge Building module in FLE3, however, the students were engaged in detailed investigations of the questions. In many ways the face-to-face interactions in front of the computer screen resembled certain aspects of inquiry learning – they tried to articulate their own explanations, they assessed strengths and weaknesses in the explanations, and they searched for information in order to provide further explanations. The talk in front of the screen was identified as the most important part of the collaborative knowledge building that took place during the scenario, but it was also found that many important questions and ideas that emerged in face-to-face interactions were never explored further. Their reasoning and deepening explanations became *temporal* and *local,* not *persistent* and *shared* in the Knowledge Building module, thus the other local group could not take part in the knowledge building and both groups missed out on the opportunity to use each others insights and knowledge in furthering their understandings of gene technology.

While the Knowledge Building module was envisaged to support the students' knowledge building in this scenario, it was primarily in the face-to-face interactions in front of the screen that we could find evidence of any kind of knowledge building. Exploring how such local knowledge building can be made more persistent and shared is seen as an interesting possibility for improvement of the learning environment. An obvious solution would be to let each student work with a separate computer, and thereby forcing them to communicate through the digital learning environment. This would probably have increased the interaction within the composed group and might have resulted in a more distributed collaborative process. It would, however, also remove the fruitful discussions between the co-located participants. Thus, it remains an open question as to whether such a solution would be advantageous for the overall learning activity.

One should never underestimate the role that the institutional dimension plays in such design experiments. Institutional aspects influenced both the design and the students' activity. In the design phase we were constrained by the availability of computers in the school in Bergen and thus had to plan for local groups that would share a computer. The design was also constrained by the curriculum where gene technology was a natural science unit of approximately 15 hours. We were, however, able to extend these hours by creating a cross discipline unit that included their religion & ethics and Norwegian hours during these 3 weeks. The result was that both science and ethical aspects were in focus during the inquiry, and there was an emphasis on writing skills in the final product. The challenges for the students were many. They were dealing with both a new subject matter (gene technology) and with a new way of working (inquiry learning) and they had to appropriate a new technology (FLE3) within a limited time frame and learn how to work with another class in another school. There is also some evidence in the empirical data (Rysjedal, forthcoming) that the students were having trouble with the "asynchoronous" nature of the inquiry process. They would post a note and then sit and wait for a response from the matched local group, but the other class might not be logged on until the next day (remember there were only 5 hours where the classes worked on *genetikk* simultaneously). This expectation of immediate response and feedback is ingrained in much traditional classroom behavior, referred to as an initiation-response-feedback (IRF) pedagogical exchange (Sinclair & Coulthard, 1975) and when they did not receive immediate response and feedback, this caused frustration. We did, however, see evidence in the local group of the Initiation-**Discussion**-Response-Feedback (IDRF) pedagogical exchange Mercer & Wegerif report on in their studies of children's talk in front of computers (Mercer & Wegerif, 1999; Wegerif, 1996).

Understanding what is going on in ICT supported scenarios is a complex process and a lot of empirical data needs to be examined in order to make sense of what is going on. In this paper we have given insight into how we try to understand how the structure and organisation in *genetikk* has influenced the way the students have worked. We cannot only look at their interactions within the local and composed group in light of the design of *genetikk*, but must always remember that it is situated in an institutional setting that not only imposes constraints on scenario design, but has also influenced student expectations and ways of working over a number of years. How all these factors can be understood, and how they influence design is a challenge to the CSCL community.

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