Examining social interaction patterns for online apprenticeship learning
Object-oriented programming as the knowledge domain

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Abstracts

English Abstract

The article shows and discusses social interaction patterns that developed in an online learning environment where the pedagogical design was inspired by ideas found in apprenticeship learning. The embedded study comprised a case study of an introductory online course on object-orientation and a design experiment carried out in the same course in the following semester. The case study indicates that support for the teacher's awareness information on the learners' level of knowledge and progression is critical for successfully developing social interaction patterns of teacher guidance. The design experiment identified that learners' pre-prepared solution of the problem was vital means for developing productive social interaction patterns concerning collective reflections and joint problem solving.

Danish Abstract

Denne artikel viser og diskuterer sociale interaktionsmønstre som udviklede sig i et virtuelt læringsmiljø hvor det pædagogiske design var inspireret af ideer fra mesterlære. Studiet bestod i et case-studie af et online kursus i introducerende objekt orientering og et design eksperiment som blev udført i same kursus semesteret efter. Case studiet indikerer at underviserens viden om de studerendes vidensniveau og progression er kritiske for en succesfuld udvikling af sociale interaktionsmønstre i forhold til vejledning fra underviseren. Design eksperimentet identificerede de studerendes forberedte løsninger af et problem som en vital hjælp til at udvikle produktive sociale interaktionsmønstre for kollektiv refleksion og fælles problemløsning.

Norwegian Abstract

Denne artikkelen presenter og diskuterer sosiale interaksjonsmønstre som utviklet seg i en nettbasert læringsomgivelse hvor det pedagogiske designet var inspirert av mesterlære. Undersøkelsen bestod av en case-studie av et nettbasert introduksjonskurs til objekt-orientert programmering, og et designeksperiment utført i det samme kurset påfølgende semester. Case-studiet indikerer at støtte for lærerens awareness-informasjon knyttet til studentenes kunnskapsnivå og progresjon er kritisk for å utvikle sosiale interaksjonsmønstre for lærerveiledning på en god måte. Designeksperimentet identifiserte studentenes individuelle løsningsforslag som en sentral ressurs for å utvikle produktive mønstre av sosial interaksjon relatert til kollektiv refleksjon og samarbeidsrettet problemløsning.

Keywords

Distance learning, apprenticeship, programming, CSCL.

Introduction

The first steps towards what we today label online learning were taken in the late 80s. Distance education institutions and universities started to realize the potential of using ICTs (Information and Communication Technology) to facilitate (adult) learners' collaboration across place and time constraints (e.g. Mason & Kaye, 1989; Harasim, 1990; Paulsen 1990; Feenberg, 1991; Kaye, 1992; Hiltz & Turoff, 1994). The ICTs implied institutional and educational changes (as discussed in Cole & Engeström, 1993). However, the changes did not seem to transcend the existing practices in terms of the new social interactions and collaboration patterns that developed with the new artefacts (See e.g. Fjuk, 1998; Fjuk & Øgrim, 1997; Rovay, 2004; Cuban, 2001; Murchu & Sorensen, 2004).

Recently, a variety of services and applications are increasingly becoming easily available from everyone's PC. In contrast to the early days of online learning, this technological situation allows to a larger extent course designers to focus on how the learning activities and corresponding learning objectives can be approached through the new ICT-mediated and online environments. An increasing number of studies have explored different issues that are valuable in this respect. For example, Paulsen (1995), Hara and Kling (2000), Salmon (2000), and Stahl (2001) explore the teachers' new roles. Others discuss how ICTs influence patterns of collaboration and social interactions (e.g. Krange, Larsen, Fjuk & Ludvigsen, 2002; Wasson & Ludvigsen, 2003), the importance for meta-communicative actions and commitment in problem-oriented learning at a distance (Fjuk & Dirckinck-Holmfeld, 1997), and various forms of awareness information related to online collaborative learning (Gutwin, Stark & Greenberg, 1995; Cao & Greer, 2003; Krange & Fjuk, 2004). Finally, some studies provide insight into the employment of pedagogical approaches that are theoretically grounded in co-located situations, such as problem oriented project pedagogy (Fjuk & Dirckinck-Holmfeld, 1997), case-based learning (Hermann, Rumel & Spada, 2001), progressive inquiry learning (Hakkarainen, Lipponen & Järvelä, 2002; Ludvigsen & Mørch, 2003) and problem-based learning (Zumbach & Reimann, 2003).

The study reported in this article is a contribution to this emerging body of research. The aim of the study was to examine the social interaction patterns that develop in online learning environments, where the pedagogical design is motivated by ideas from apprenticeship learning. Apprenticeship learning is theoretically anchored in situations different from online and educational situations. Few studies have explored what social interaction patterns that develop amongst learners and between learner and teacher in online apprenticeship motivated learning environments. The identified interaction patterns provide

insights into how social interaction amongst learners and between learner and teacher improve collective construction of knowledge, and how to integrate these patterns in future course designs.

The knowledge domain of the study was *Introduction to Object-Oriented Programming* (IOOP), delivered by the University of Aarhus in Denmark. The distributed organization and extensive application of ICTs represented in this online course design was regarded as potentially illuminating towards exploring a subset of social interaction patterns, given the particular knowledge domain. The patterns were identified by using *interaction analysis* in rich combination with online observations and in-depth interviews with learners and the teacher.

The following section presents IOOP in terms of learning objective, pedagogical approach, and the design of the networked learning environment. Next, our research approach is described, followed by a section presenting and analysing data from the study. This article concludes with a section discussing the main findings, and a conclusion proposing some implications of our research for design of online learning environments.

Course design considerations

To examine the social interaction patterns and how the social interactions influence collective knowledge construction, it is vital to relate the analysis to the subject matter (object-oriented programming) and the original online course design. Thus, this section first gives a brief overview of the course under study and its principal learning objective. Next, some interpretations of apprenticeship learning are introduced and discussed in relation to the particular course. Finally, this section describes the application of these facets of apprenticeship in the online course design.

The learning objective

The course *Introduction to Object-Oriented Programming* (IOOP) has been taught as an on-campus course at Aarhus University in Denmark during the last decade. The principal learning objective is the *processes of programming*, rather than the final products (e.g. a program written in Java). Programming is arguably a creative and analytical activity where the programmer starts with a vague idea of a solution, then – in some non-formal and non-linear way – articulates and models the thoughts into an executable program. A pedagogical approach that enhances such a creative activity in itself, in rich combination with showing the learners how an expert programmer works in these processes, has gradually been considered vital for the course design. However, modern pedagogical perspectives that emphasise an understanding of language, culture and the cognitive development that occurs through interactions between learners as well as between learners and teachers (Scott, Cole & Engel, 1992) have not been consciously included in the on-campus course. The online learning course design aimed at incorporating collaborative knowledge building processes. In this perspective, learners actively generate, access and organise information, constructing and refining their own knowledge through feedback from peers and the teacher.

The pedagogical approach

The most significant source of inspiration behind the pedagogical approach was conceptual frameworks offered by apprenticeship learning. Traditionally, theories on apprenticeship learning concern the learning of a craft in the community of practice where the work is carried out (Lave & Wenger, 1991; Lave, 1996; Nielsen & Kvale, 1997). Through social interactions between the experienced master and the apprentices, the apprentice progressively creates a deeper understanding of the profession (Aboulafia & Nielsen, 1997). Nielsen & Kvale (1997) describes two facets of apprenticeship: the person-centred facet and the de-centred facet. In the *person-centred facet*, the teacher reflects and thinks aloud about the particular action, making it visible and a source of identification (ibid.). As such, the learner creates meaning in observing the teacher performing the actions embedded in the profession (such as the creative and analytical activity of programming). Furthermore, the teacher's comments on the learner's practice have important bearing on the learner's 'reflection in action' (Schön, 1983). In the *de-centred facet* of apprenticeship, knowledge construction is considered as a kind of legitimate peripheral participation (as described by Lave & Wenger, 1991). The attention is on the learner's participation in a community of practitioners where the teacher or a more experienced peer legitimizes the skills and knowledge of the individual learner. Mastery does not reside exclusively in the teacher alone, but in the community (of which the teacher is a part) and on the structuring of the community's learning resources (ibid). In most situations, a dynamic balance between the person-centred and the de-centred facet is practiced.

The conceptual framework of cognitive apprenticeship (Collins, Brown & Newmann, 1989) offers insight into how aspects of apprenticeship learning is applied into formal education and schooling. A central concept herein is modelling that is "supposed to give models of expert performance. This does not refer only to an expert's internal cognitive processes, like heuristics and control processes, but also to model the expert's performance, tacit knowledge as well as motivational and emotional impulses in problem solving" (Järvelä, 1995, p. 241). The teachers give the right level of support while the learners are solving problems. An important issue of cognitive apprenticeship is that the learners' reflection on the differences between her / his knowledge and the reflections made by the master and fellow learners.

The frameworks offered by cognitive apprenticeship, person-centred apprenticeship and de-centred apprenticeship gave inspiration for the course design. A common assumption in these frameworks, however, is the co-location of the actors (teacher and learners), which was not the case in IOOP. The interaction frameworks of *teleapprenticeships* offer some insight into this problem area. Teleapprenticeships are teaching frameworks for apprenticeship-like environments without requiring the actors to be in the same places at same times (Levin & Waugh, 1998), and to support learning in the context of a remote practice. The frameworks allow novices to learn through participation in a remote community of practice, initially observing the online interactions, then handling small tasks to accomplish with guidance and finally taking roles that are more substantial during the extended interaction. This approach differs from the online IOOP course in a significant issue: The learners are taking part in an online community of learners and teacher, and not in an online community of professionals. Their daily work situation maintained their commitments to a community of professionals.

The focus in IOOP is on showing the learners how a professional thinks and acts in a complex process of analysing and solving problems, i.e. modelling in the cognitive apprenticeship terminology. A vital aspect of the online course design was then to organize ICT-based applications that were easily accessible from the learners' PCs (preferable from their homes) and that provided quality given the pedagogical constraints.

The online learning environment

To organise a dynamic mix of the pedagogical constraints found in apprenticeship learning, it first implies instruments for enhancing information sharing and joint creation of meaning amongst the learners. Second, it implies instruments for supporting the teacher's reflection in action in terms of both natural and scientific language, as well as for showing the creative process of programming. Finally, it implies instruments for supporting awareness information on the learner's knowing and progression [1]. In the following, we will focus on the instruments most central in organizing the online learning environment: the *online meetings* and the *assignments*. Fjuk, Berge, Bennedsen, and Caspersen (2004) give a more thorough account of the course design.

The online meetings were mediated by real-time video streaming of the teacher's PC screen, showing his usage of the various (programming) tools. Figure 1 shows an example of how the video stream appears for the learners. In the corresponding audio stream, the learners can hear how the teacher reasons and thinks aloud about the problem; an externalization of the teacher's internal processes "Seeing how experts deal with problems that are difficult to them is critical to students' developing a belief in their own capabilities. Even experts stumble, flounder (...) Witnessing these struggles helps students realize that thrashing is neither unique to them nor a sign of incompetence" (Collins & al., 1989, p. 473). In order to support interactions amongst learners and between learner and teacher during the online meetings, a text-based *Instant Messaging (IM) conference* was set up in conjunction with the real-time audio- and video streams.

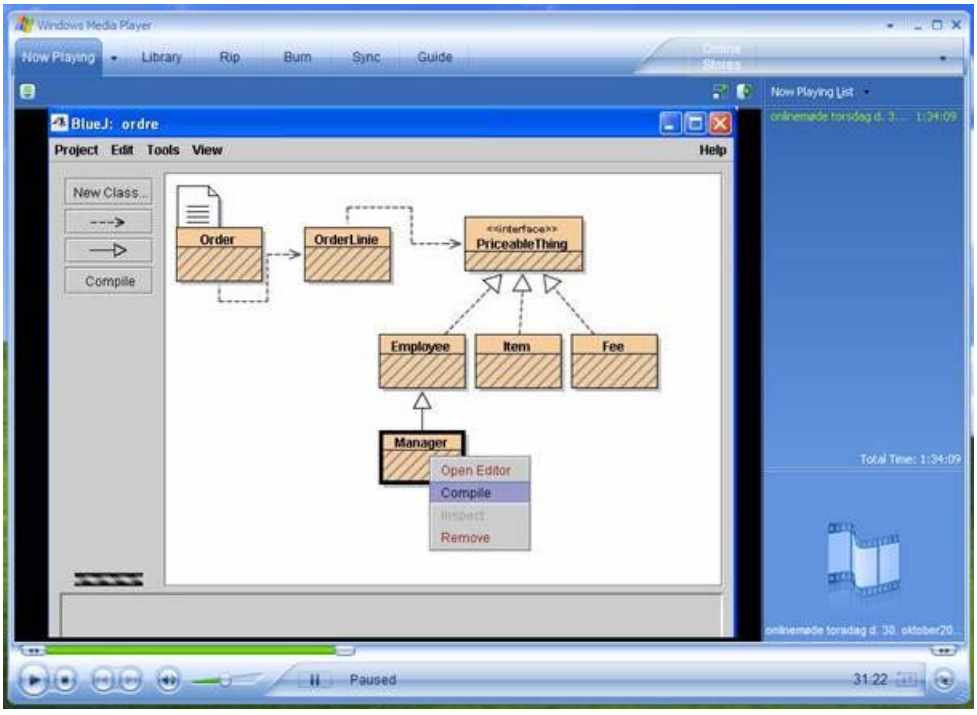

Figure 1. The streaming of the teacher's PC-screen to the learners.

The learners got a number of weekly *assignments*. The aim of the assignments was two-fold: First, they should afford individual knowledge construction concerning the programming language Java, as well as provide practical and hands-on skills on e.g. the execution of program codes. Second, they should maintain awareness information to the teacher regarding the learner's knowing, development and progression.

Research approach

To examine the social interaction patterns that developed in the online apprenticeship-motivated learning environment, two primary research activities were conducted. The first was an exploratory case study (Yin, 2003) of IOOP during the fall 2003 semester, conducted by the second and third author. The second was a design experiment (Brown, 1992) conducted during the spring 2004 semester of IOOP, aimed at further exploring critical issues identified in the case study. The first and third author designed the experiment, and the first author carried it out. The three authors have analyzed data from the design experiment jointly.

Case study

The aim of the case study was to examine online apprenticeship learning in *a real delivery situation*. The course was a part of the MS program in Software Construction with 22 participants. Most of the learners were committed to a daily work situation for which the course content was significant. All the learners had programmed in their daily work, although not necessarily using an object-oriented approach. The course started with a weekend seminar (on campus) and concluded with the final exam five months later.

Since the online meetings constituted a central mechanism for operationalizing the apprenticeship approach (see the section 'Results from the case study'), they came to be the basis of our analysis. The data was gathered by *online observation* of the online meetings, where the researchers were present in the shared space, but did not participate in the online interactions. During the course, 14 online meetings took place. The meetings started at 8:30 p.m. on Thursday nights, typically lasting for 1½ hour. Furthermore, recordings of the audio- and video streams from the teacher and logs of the corresponding Instant Messaging (IM) sessions constituted the basis for *interaction analysis* (Jordan & Henderson, 1995). This latter approach provided us with the possibility to examine to what extent the social interactions influenced collective meaning-making and knowledge constructions amongst the learners, and how the technological artefacts were used to support certain actions and the social interactions between learners and teacher. Another important aspect is that the experiences of the learners become visible and documented in the "temporal orderliness and project ability of the events they construct" (Jordan & Henderson, 1995, p. 61).

In-depth interviews with nine learners were carried out just after the final exam. The interviews lasted approx. 30 minutes each. Two interviews were conducted with the teacher: a one-hour interview at the

outset of the semester, and a 90-minute interview at the end of the course. The learners' and the teacher's talks as well as the observation notes constituted rich supplements to the analysis of selected transcripts of the recordings.

Design experiment

A design experiment was conducted as a follow-up activity of the case study, and took place during week 6 of the 15-week course in the spring semester 2004. The aim was to explore critical issues identified during the case study, with a particular focus on learners' collaboration. Design experiments differ in interesting ways from both laboratory experiments and naturalistic investigations (Brown, 1992). Ludvigsen & Mørch (2003) put it very clearly this way: "Design experiments can been seen as intervention in the educational practice since the researchers, in collaboration with teachers, try to change the way the students work. These shifts often presuppose a change in participation structures and how agency and division of labour are distributed between teacher and the students" (Ibid, p. 67).

The delivery situation in spring semester of 2004 was close to identical with the delivery situation in fall semester 2003 (presented in the section on Course considerations): The design, content and objectives, and the learners were part-time learners committed to a daily work situation. However, the course was delivered as part of the MS programs in *ICT and organization* or *multimedia*. Another major difference was that a new teacher replaced the one from the preceding semester. Twelve learners attended this semester of the online course. The primary motive for many of the learners was to get an insight into how a programmer works and not necessarily to become a programmer themselves. Ten learners participated in the experiment, formed into three groups: Group 1 through 3. Groups 1 and 2 were guided by the fall 03 teacher, group 3 by one of the (two) original course designers. The groups were formed from the beginning of the course, based on home address in order to ease physical meetings among the group members. All the groups had collaborated (in co-located settings) before the experiment.

All groups had the same task of modifying and extending a program that could keep a schedule of marriage reservations for a church. This problem was divided into four sub-tasks to cover different parts of object-orientation and the programming process.

Due to the focus on the social interaction and collaboration amongst the learners, it became vital to study the learners' creation of joint understanding through a collaboration tool. The collaboration tool Centra includes functionalities such as a (shared) whiteboard, text-based chat, audio facilities, and application sharing (Centra, 2004; Estes, 2004). As in the case study, the online activities were recorded for later interaction analysis. Group interviews, also administered through Centra, were conducted immediately after the final online session.

In the following, we will describe, analyse and discuss social interaction patterns arising when taking apprenticeship learning online using the many sources of information.

Results from the case study

Other research (Fjuk & Berge, *forthcoming*) based on online observations and interaction analysis of the online meetings shows that the learner activity (in the textual IM conference) was modest. The teacher made deliberate attempts at inspiring engagement and social interactions amongst the learners. This was e.g. achieved by taking pauses to ask for suggestions and reflections on a problem. Overall, the teacher's efforts to stimulate the learners to become more active during the online meetings were only moderately successful. This is in line with the findings reported by Levin & Waugh (1998) on teaching teleapprenticeships. Here the authors found that the benefit of online interactions was not enough to overcome the costs, since it was easier meet face-to-face for communicating. However, the learners had reduced possibilities to meet physically. In the IOOP case, one complicating factor in the interaction between the teacher and the learners was the delay in the video/audio stream of about 30 seconds, while the IM was close to instantaneous. Even though the teacher responded to an IM entry immediately using the video stream, the learners did not receive the response until approximately 30 seconds later. It should be noted that both the teacher and the learners adjusted to this constraint during the course. Other constraints that were brought up were problems due to typing speed or a reluctance to "speak in public". Another issue, raised by a learner in our interview, was of a more technical nature:

"Well, sometimes when [the teacher] asked a question, I needed to see a part of the code that was not visible on his screen. It was hard to answer the question without scrolling his code window".

Despite the issues brought up here, both the teacher and most of the learners interviewed stated that all-in-all they found the technical solution to be rather unproblematic.

The interaction analysis of the transcripts (from the online meetings) shows that the online meetings did not develop into a professional discussion amongst the learners. Hence, the interaction analysis in itself did not provide confirmation regarding collective development of understanding and individual learning effect of social interactions (Berge and Fjuk, *forthcoming*).

The interviews with the learners, however, indicate an individual learning effect of taking part in the online meetings. Several of them emphasized that they have constructed new conceptual knowledge on object-orientation that was immediately applicable for their daily professional practice. Thus, this part of online apprenticeship seems to have been reasonably successful in the sense that the teacher's ways of showing (modelling) the processes of programming and verbal reflections on these actions were considered vital by the learners. In the interview after the final exam, one of the learners articulated his view on this in the following way:

"[the teacher] has a basic idea about what he shows and teaches (...) his way of articulating this is important (...) [the teacher]'s way of showing the themes has definitely been important for a totally new experience on what object-orientation is"

The modest social interactions amongst the learners in the online meetings contradicted the teacher's needs for awareness information on the individual learner's knowing and progress in order to scaffold them. Arguably, the weekly assignments were also important instruments in this respect (emphasized by learners in interviews). Still, they are limited to afford evaluation of the *final products* or solutions of the learner's work. These solutions can only shed light on the learner's problem solving *processes* to a modest degree. To be able to scaffold and help the learner's reflection on the learners' programming process the teacher stated the following need in the second interview:

"If I could participate in problem solving together with the learners, I would get a much better feel for – in

detail – what issues that are problematic for them".

Concluding, the case study has raised some issues that we have found important to investigate in understanding of the master-role. The first issue concerns conditions for productive learning through dialogues and collective activities so that the teacher not solely carries out the master-role. The second issue concerns conditions connected to the teacher's participation and legitimating roles in order to qualify the master's possibility for scaffolding and initiate reflections. These issues were brought further into the design experiment.

Results from the design experiment

The experiment was conducted in two phases: In the *first phase* each group was given a short introduction to the functionalities of the collaborative tool Centra. The group was expected to create a shared understanding of the pre-defined problem, and agree on a division of the work amongst them. The teacher's role was to take part in the dialogue by asking critical questions and by guiding the learners to a common understanding. In the *second phase* - the actual problem solving process - the teacher's role was to legitimize the learners' actions and to scaffold when the learners encountered breakdowns in their collaboration. The teacher should also initiate reflections by discussing the learners' solutions as compared to how a professional programmer typically would solve such a problem.

The patterns of social interactions

In what follows we show and discuss the social interactions that developed for each of the three groups. Extracts from transcripts connected to the collaborative solving of the first sub-task are selected. The objective of this task was to create a set of so-called object diagrams. An object diagram serves as a visual description of the state of a program code at a given time of execution. The problem addresses a central issue in object-orientation: the distinction between classes and objects. The task has one correct solution. The analysis indicates that each group developed different social interaction patterns during their problem-solving process.

Group 1: Collective reflections on an individual contribution

During the first session, the group agreed that they should make an outline of a solution individually before session 2. At the outset of session 2, the group spent approximately four minutes on agreeing on a strategy to approach the problem. Then Kristy displayed her proposal, shown in figure 2(a). The following dialogue ensued [2]:

Extract 1. Collective reflections

1	Kristy	I was in a little doubt about if those methods should be included in the object diagram. There aren't many examples in the book. What do you think?
2		(6,0)
3	Thomas	I think the same as you, there are really not many examples of how one should make such object diagrams. Ehh, I have actually not seen any where methods, relations, or such are included before. So, I am in doubt as to whether if, if they should be included – when I have seen them, there are usually only the four objects one see, eh, by themselves.
4		(5.0)
5	Kristy	The reason I have included them is the way the task is formulated. That one ... first in line 15 one should draw an object diagram, and again one should draw an object diagram at line 18 and line 21, and if one shouldn't include the relations, then it would be only the four objects and therefore no reason to draw the object diagram several times.
6		(12.0)
7	Thomas	No, that is correct. But then one should, as I see it, draw four object diagrams, where the first object diagram, that is only the four, ehh, independent objects, and then you get the relation on, one has the relation from the first, P1 loves P2, and, and P2 to P1, then one takes that diagram and ((inaudible)).
8		(8.0)
9	Kristy	You might very well be right, Thomas. Uhm, it might be because this example, the driver class, seems a bit, ehh, what is it called, it seems a bit much to make four so simple diagrams instead of creating one all together. It is still easy to get an overview.
10		(6.0)
11	Thomas	Neil, what do you think about this?
12		(5.0)
13	Neil	Yees. At the outset, it seems, it looks very useful, it gives a structure, a very good structure. Where I am in doubt, that is if it follows the rules as such, but there is no doubt that, as I know the task, that it is a picture of, of the issue
14		(5.0)
15	Kristy	Should we ask Teacher?

In line 1, Kristy starts by pointing to an issue of uncertainty for her. She opens for discussion by inviting comments from the other learners. The 6-second pause indicated in line 2 is to some extent accounted for by a feature of Centra, which is that only one participant can speak at a time. The transfer of control of "microphone ownership" takes 4-5 seconds. In line 3 through 9, Kristy and Thomas seem to establish an

agreement that relations between objects should be represented, but they are unsure about how. Then, Thomas invites Neil to offer his opinion. Neil, who has not participated in the discussion so far, seems to agree that the relations should be represented, but expresses concern about notation. At this point, Kristy suggests that they ask the teacher for guidance.

One characteristic of the extract shown in extract 1 is that the learners offer their understanding of the topic, and that they to some extent build on each other's utterances towards establishing a shared understanding. The point of departure for the discussion was Kristy's somewhat incorrect proposal (shown in figure 2(a)). This was, at the outset, displayed in the shared workspace for approx. ten minutes, and then for approx. five minutes later on. While the diagram was displayed, the learners repeatedly referred to it; one example is found in line 7, where Thomas refers to P1 and P2. Serving as both a means for supporting Kristy's initial understanding and as a common frame of reference during the following discussion, the diagram seemed to have a central position in the collaborative endeavour. After 20 minutes, the group chose to make a new diagram from scratch using the shared whiteboard. During the next 20 minutes, the group used this as a fundamental means, and arrived at an almost correct solution (figure 2(b)).

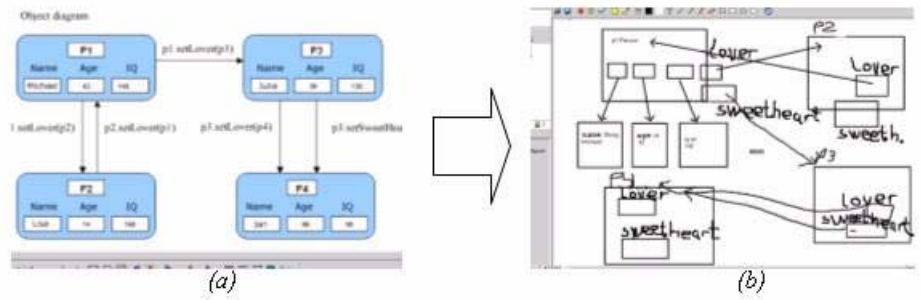

Figure 2. The initial solution (a) made by one of the learners and the final solution (b) made in collaboration.

Group 2: Joint solving of the problem through teacher legitimated actions

During the first session, group 2 agreed that everybody should individually reflect upon how to approach the problem and ideally make an outline of a solution. However, none of the learners had prepared a solution for the second session. The group spent the first 14 minutes to discuss what tools and approaches to use to solve the problem. The teacher intervened in the discussion, suggesting that they use the shared whiteboard. Then the following social interactions developed:

Extract 2. Joint problem solving through teacher legitimated actions

1	Karen	Is there any one of you that have a bid for how to start, or should we just start to draw, or what?
2		(8)
3	Mary	I can try start try drawing, and we can see if it turns out very wrong ((laughter))
4		(6)
5	Teacher	Good. It is important, Mary, while you draw that you activate that lock, and tell us about what you are doing. Because, otherwise, the rest of us does not have the possibility to say something or to comment, or something else. Moreover, you others can raise your hand and say, ... if you would like to speak.
6		(8)
7	Mary	OK, Ehmm. I would like to, I will try and see if I can draw an object diagram that, based on the class Person, that of course is described in the task, but I will do it with reference to page 53 in the book where there is something about object diagrams, because that is one of the things, I think, I am confused about. I reckon I will get some comments as I go along.
8	Mary	((Draws a rectangle))
9	Mary	The first thing I would like to try to make is this very nice rectangle. Moreover, it is meant to illustrate the new object.
10		(7)
11	Mary	And it should have an... How does one write, Teacher?

After the opening comment from Karen, Mary takes on the responsibility of drawing the object diagram. The latter part of her statement in line 3 indicates that she is quite defensive about her ability to make a correct solution. In line 5, we see that the teacher intervenes with advice about how the group can work, including instructions about the functionality in Centra (microphone "lock" and "raise your hand"). Again, in line 7, Mary states that she is uncertain about how to draw object diagrams, and she invites comments from the others. She proceeds by drawing a rectangle, and then asks the teacher a question about functionality in Centra.

This extract indicates a characteristic issue of the social interactions in group 2. The learners were open with regard to the correctness of their suggestions, and they frequently sought to legitimatize their actions with their peers or the teacher. Moreover, the group proceeded hesitatingly, often not making much progress until the teacher intervened. The group spent a total of 56 minutes to arrive at an outline of an object diagram that was close to correct (figure 3).

Figure 3. The final solution made in collaboration.

Group 3: Monologue

During the first four minutes of the session, the teacher explains how to use Centra and suggests a form where the learners take turns presenting their solutions. He also encourages comments or questions from the other learners during these presentations, and informs that he will take a passive role. Ray volunteers to present his solution first and displays the diagram shown in figure 4(a). Then the following dialogue took place:

Extract 3. Monologue

1	Ray	What I have done here, first, is of course to set the state that the objects have where it is stated that we should draw the object diagram
2		(12)
3	Ray	Is there anyone who has any comments to this first one?
4		(2)
5	Peter	Yes, you sent this one to me yesterday, Ray, and I have looked through it. What I was thinking, I'm a bit puzzled that you have taken the regular types, string and int, and drawn them as, what is it called, independent objects. I know that string is an independent object, ehhh, but I am actually in doubt whether int is an independent object. But would one usually do that in an object diagram, could we discuss that?
6		(5)
7	Ray	I don't know. It is possible that one should bring them inside, so that one can see what the value is. Maybe you could comment on that, Teacher?

Ray sets out with a high-level comment on his diagram (see figure 4(a)). His use of the term "of course" could indicate that he is confident regarding the correctness of his proposal. However, after a 12-second lapse, he opens up for discussion by requesting comments. The diagram is almost correct; it is actually very similar to group 2's final solution. Peter directs the attention to the only error in the diagram. In line 7, Ray suggests the correct solution and asks the teacher for comments. During the next 10 minutes, Ray, Peter and the teacher discuss Ray's three object diagrams at an advanced level.

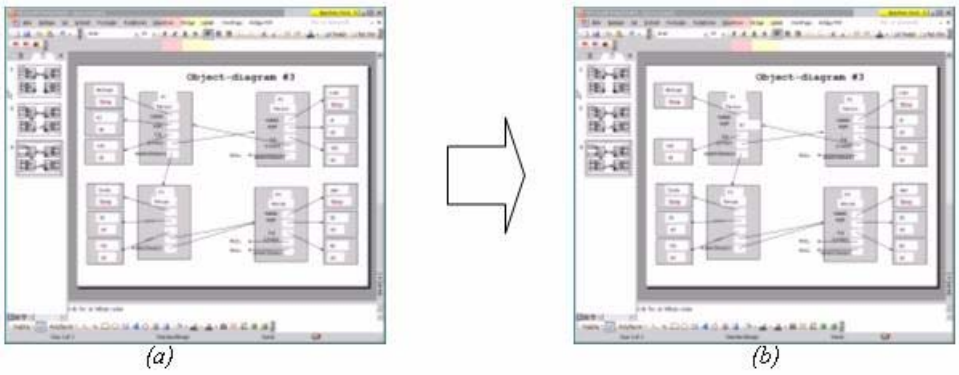

Figure 4. The initial solution (a) made by one of the learners and the final solution modified by another learner (b) in the shared application.

In this period, two of the learners (Lea and Judith) did not take part in the social interactions. Then, after Ray has suggested that the group move on to the next task, the teacher asks if Judith and Lea have any comments. Lea shows her prepared solution, and the social interactions for the remaining 30 minutes were based on her suggestion.

The dominating role of the teacher is one striking feature of the interaction in group 3. An examination of turn-taking shows that the teacher controlled the microphone more than half of the total time. In comparison, the other teacher was in control for 18 % and 23 % of group 1 and 2, respectively. Table 1 shows how much of the time each participant in group 3 either spoke or was active in terms of a shared tool

(e.g. the whiteboard), and how many times during the session each learner was "in control" of the microphone, the shared application, or both. In addition, the table shows pauses, meaning time spans where there were no actions in the shared space.

Table 1. Turn-taking in group 3

Participant	Total time	% of time	Number of turns
Ray	03:29	7 %	21
Peter	03:50	8 %	10
Judith	01:09	2 %	7
Lea	03:10	7 %	17
Teacher	25:47	53 %	36
Pause	11:00	23 %	63
Total	**48:25**	**100 %**	**154**

This strong presence is in contrast to the teacher's stated intention, as described at the start of this section. The discussions departed from the learners' understanding as expressed in their object diagrams, questions and comments, and the teachers' contributions were of a lecture-oriented character. It became apparent early on in the session that a monologue-like interaction was the pattern characterizing this group. Although the group arrived at a correct solution early on, they did not explicitly agree on one common solution.

Summary and conclusion

This research was aimed at examining the social interaction patterns for online learning environments of which the design is inspired by ideas of apprenticeship learning. The first part of the embedded study was a case study conducted in fall semester 2003. The second part of the study was a design experiment conducted in spring semester 2004, aimed at exploring critical issues found in the delivery situation of the previous semester. Both these studies identified some issues that are interesting for further pedagogical designs of online learning environments.

The online course design was motivated by ideas found in apprenticeship learning and included a dynamic balance between the following: ICT Support for information sharing and joint creation of meaning amongst the learners; Online support for the teacher's reflection in action in terms of both natural and scientific language, as well as support for showing and legitimating the creative and analytical process of programming; Support for awareness information on the learner's knowing and progression. In the original online course design, the weekly online meetings constituted the primary instrument for maintaining this balance. However, the case study shows a modest level of social interaction amongst the learners in these meetings. A fundamental awareness instrument for the teacher to achieve insights into the learner's knowing and progress was thus almost absent. Therefore, it was difficult for the teacher to legitimate the knowledge of the learners. Disregarding the IM component, the video and audio streaming technologies used (Windows Media Player) have a functionality that implicitly supports an information transformation style, with no opportunities for feedback from the audience. This functionality proved to be well suited for practicing the important aim of showing the learners how a professional programmer (the teacher) reflects and reasons in the creative process of programming. The interviews also indicate that the learners did get a deeper understanding of observing the teacher's actions and reflections. Hence, this particular idea from apprenticeship learning seems to have been successfully transformed to the online environment. Outlined from the case study, the interaction pattern predominant in the online meetings was that of traditional lecturing. The critical condition in this respect seems to be *the teacher's awareness on the learners' knowing*. This condition can be maintained through different activities. An example is meta-communication in terms of questions, pauses, and exercises.

The intervention study provided additional insights. Our interaction analysis suggests that an individual learner's prepared solution (before the group session) shaped the group's interaction patterns. Prepared proposals thus seem to be a critical condition for successful collective knowledge construction. The analysis, however, also indicates that a pre-prepared suggestion in itself should not be considered in isolation. In addition, how its creator articulates the suggestion might be of importance in an online setting. In group 1, the learner who presented her suggestion made clear the challenge she met in solving the problem, and sought other alternatives and explanations from the co-learners. In this way, the presenter invited collective reflection upon the pre-prepared suggestion. This initial social interaction pattern – *Collective reflection on an individual contribution* – characterizes the group throughout their online collaboration, and resulted in a new and more correct solution to the problem. In contrast to group 1's pattern of social interaction, group 3 developed a *monologue* pattern. In this group, the presentation style was more like a lecture on a correct solution. In contrast to group 1 and group 2, we understand this pattern of collective activity as not very productive regarding the development of collective reflection upon the shared artefact. Group 2 started out without a proposal for an object diagram. The group proceeded hesitatingly, often depending on the teacher's scaffolding for moving on. We propose that the group's interaction pattern was shaped by the lack of a common reference manifested in a draft object diagram.

Furthermore, the teacher seemed to have an important role in guiding the learners to a joint and correct solution. The learners considered these scaffolding actions important. This was most apparent in groups 1 and 2, in contrast to group 3, where the teacher engaged in a more traditional lecturing role. In groups 1 and 2, however, the teacher extensively performed meta-communicative actions. These communicative actions encouraged the individual learners to articulate and to make their interpretations and thinking explicit, facilitating for construction of a deeper individual understanding. They also provided means for the teacher to gain insights into the learners' understanding as well as guiding the process of programming and conceptual understanding – rather than the traditional way of commenting on the final solution only.

The findings from the study are not new regarding theories on learning and human development. It is in line with well-known learning theories that emphasize the mutually consisting processes of individual and

collective activity (Engeström, 1987; Lave & Wenger, 1991; Kaptelinin & Cole, 2002). As Kaptelinin and Cole (2002) put it: "(...), not only does collaboration between the learner and other people change some pre-existing individual phenomenon, but also directs and shapes both the general orientation and specific content of individual development" (Ibid., p. 304). The interaction analysis indicates, however, the importance of deliberately incorporating this duality in an *online learning design*, by organising for individual activities (preparation of suggestions for solutions) and for collaborative activities through open and peer legitimating actions. Others also discuss this critical issue. For example, Krange and Fjuk (2004) emphasise the opportunity of changing between closeness to collaborative peers through e.g. shared ICT-application and distance to peers in order to articulate thoughts through reflection.

Based on our study, we suggest that the primary and critical condition is a pre-*prepared suggestion for a solution*. Such a shared artefact constitutes an important communicative instrument for establishing productive collective activities online. However, this condition's success is dependent on an open and legitimating social interaction pattern to reduce the chance of developing a monologue pattern. We advise that future online course design carefully integrate this condition and its requirement. In addition, attention to supporting the teacher's awareness information regarding the learners' level of knowledge and progression is critical when approaching online apprenticeship learning environments. A certain level of meta-communications in terms of questions, pauses, and exercises seem to be a requirement in this respect.

Acknowledgements

The study reported in this article was conducted as part of the project Comprehensive Object-Oriented Learning (COOL), funded by the Norwegian Council of Research. In addition, special thanks to Jan Arild Dolonen, who took actively part in the design of the experiment reported in this article. Furthermore, we would like to thank Marianne Georgsen for her valuable comments on an earlier version of this article.

[1] See Dourish & Bellotti (1992) for the introduction of the term. Awareness is here understood as an understanding of the activities of others, which provides a context for one's own activity. See also Krange & Fjuk (2004) for discussion on its pedagogical application area.

[2] The text in all the transcripts and diagrams is translated from Danish by the authors.

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