Peer Collaboration and Mediation in Elementary Students’ Lamp Designing Process

Kaiju Kangas & Pirita Seitamaa-Hakkarainen,
Department of Teacher Education, P. O. Box 8, 00014 University of Helsinki, Finland
kaiju.kangas@helsinki.fi, pirita.seitamaa-hakkarainen@helsinki.fi

Abstract: The present study examines peer collaboration during elementary students’ lamp designing process. By exploring how different aspects of discourse relate to each other as well as to the various tools being used, we aimed to unfold the nature of the collaborative design process. The video recorded design episodes of one student team constituted the data source of the study. Along with the analysis of the main design activities of the process, we created CORDTRA diagrams for analyzing the interaction and the use of tools. The results indicate that the lamp designing process was a successful learning process. Through repeated cycles of designing, and by simulating many professional design practices, the young students were able to collaboratively develop a design, where various constraints determining lamp and light designing were taken into account.

Introduction
The complex and multidisciplinary nature of designing calls for intensive collaboration across different domains. The activities of those in the design professions are often based on teamwork combining several fields of distributed expertise. Consequently, the use of collaborative settings in the area of Design and Technology (D&T) education has increased. Successful collaboration in D&T contexts appears to be based on authentic design tasks that allow students to confront the multidisciplinary characters of design practice (Murphy & Hennessy, 2001; Seitamaa-Hakkarainen, Viilo, & Hakkarainen, 2010).

Professional design activities rely on the use of different tools and design representations, such as sketches and notes (Al-Doy & Evans, 2011; Goel, 1995). Particularly sketching has a crucial role in generating, developing, and communicating ideas; it is both a powerful form of thinking and the fundamental language of design (Seitamaa-Hakkarainen & Hakkarainen, 2000/2004; Welch et al., 2000). In the context of D&T education, the interaction with two- and three-dimensional models (sketches, prototypes) offers students direct possibilities to explore and evaluate a proposed solution’s form and function. Involving students in modeling practices can help them build domain expertise, epistemological understanding, and skills to create and evaluate knowledge (Schwartz et al., 2009).

In D&T settings material artifacts and tools have a central role in mediating the learning process; the design process involves parallel working through conceptual reflection and material implementation. However, research has shown that novice designers rarely use two-dimensional models, i.e., sketching, but tend to move immediately to three-dimensional modeling (Welch, 1998). Furthermore, when sketching or other forms of modeling occurs, they are primarily used for illustrative or communicative purposes, hence reducing the epistemic richness of the practice (Schwartz et al., 2009).

The present study describes an elementary students’ collaborative lamp designing project, where the guidance was provided by a professional designer. We focus on design activities of one student team, and examine how their collaborative process unfolds. By opening up the process, the present study aims to shed more light on how different aspects of discourse relate to each other, and how the various tools and design representations being used mediate the process. We addressed the following specific research questions:

1) What was the nature of elementary students’ collaborative design process?

2) How did the tools and design representations created and used during the process mediate the design collaboration?

As noted by Hmelo-Silver and her colleagues (2008; Hmelo-Silver, 2003), understanding collaboration and mediation requires going beyond coding individual speech acts. They proposed the use of Chronologically-Oriented Representations of Discourse and Tool-Related Activity (CORDTRA) diagrams as one way of achieving information about how social interaction and representations serve as tools for students’ collaborative thinking. The diagrams enable a researcher to combine the chronological picture of the coded discourse with other learning activities (Hmelo-Silver, Chernobilsyky, & Jordan, 2008). In the present study, we produced a CORDTRA diagram from the student team’s face-to-face peer collaboration, in order to visualize their interaction and the use of different tools.
Peer Collaboration and Mediation in Design Learning

We frame our study in sociocultural theory, since it provides an appropriate theoretical framework for understanding the complexity of collaborative design learning. Sociocultural and socio constructivist theories emphasize the socially situated nature of learning (Palinscar, 1998) and the critical role of tools that mediate learning (Cole, 1996). In the present study, we focus on peer collaboration and the role of tools and representations in design learning.

Peer collaboration refers to interaction that occurs when students with incomplete but rather equal levels of competence share their ideas in order to jointly solve a challenging problem (Damon & Phelps, 1989; Goos, Galbraith, & Renshaw, 2002). The development and maintenance of the shared thought process is a central element in peer collaboration (Azmitia, 1988, Teasley & Roschelle, 1993); it is a reciprocal process of exploring each other’s reasoning and viewpoints in order to construct a shared understanding of the task (Goos, Galbraith, & Renshaw, 2002). Barron’s study (2000) revealed three aspects defining good collaboration: mutuality, joint focus of attention, and shared task alignment. Mutuality refers to reciprocity with potential for all participants to meaningfully contribute, joint attention to the degree which attention is jointly focused, and shared task alignment the establishment of a collaborative orientation toward problem solving. In D&T contexts, successful peer collaboration is a process in which students actively work together in creating and sharing their design ideas, deliberately making joint decisions and producing shared design objects, constructing and modifying their design solutions, as well as evaluating their outcomes through discourse (Hennessy & Murphy, 1999; Rowell, 2002).

The problem solving strategies and practices of designing can be used for learning something else than design (Davis et al., 1997), for example, mathematics (Jurow, 2005) and science (Fortus et al., 2004; Kolodner, 2002; Kolodner et al., 2003; Roth, 1998). In designing, the interaction with tools, concrete objects and materials is a central aspect and offers a potentially supportive environment for vital collaboration, i.e., for developing shared objects and understanding (Hennessey & Murphy, 1999; Johansson, 2006; Murphy & Hennessy, 2001; Rowell, 2002). Through social interaction and visualization, design ideas, proposed solutions, and decisions are made verbally and visually explicit and visible, and joint decisions can be made. Various external representations (graphical and physical) in various phases of the design process provide different kinds of prompts to test the design ideas (Al-Doy & Evans, 2011).

A review of the research examining the role of sketching for design professionals (Welch et al., 2000) shows that sketching has a crucial role in generating, developing, and communicating ideas; it is both a powerful form of thinking and the fundamental language of design. Consequently, sketching is seen as central to developing capability in D&T education. In the early stages of designing, sketching helps to define and clarify the task, and explicate the needs constraining the task. It also enables and encourages the designer to “play” with ideas, which is essential in creative problem solving. Furthermore, sketching facilitates the evaluation of ideas and elaboration of the design task. In addition, sketching can be used to communicate the design ideas with others; it also enables those others to contribute to the ideas (Al-Doy & Evans, 2011; Welch et al., 2000). In other words, various design representations allow students to interact with one another through the design object itself, as collaborating participants’ activities are mediated and made visible through them.

Method

Participants and the setting of the study

The lamp designing project was a part of larger study that was organized in an elementary school located in a middle-class suburb of Helsinki, Finland. 32 students (13 boys), aged 10–11 years participated in the project; out of these, 7 students had linguistic or other educational problems. Ten computers were available for students working in the classroom; the teacher had her own computer and a data projector. The technical infrastructure of the project was provided by Knowledge Forum (KF, Scardamalia & Bereiter, 2006). During the lamp designing phase, the class collaboratively created the “Lamp Designing” view - a kind of on-screen workspace or bulletin board of present activity (with archives) - in the Knowledge Forum database.

The lamp designing phase lasted 11 sessions (one session was 45–135 minutes, depending on the class schedule) during a period of two months. The design process was carried through in 13 teams of 2–4 students, by sketching, drawing, and building prototypes or models. The students also regularly presented their designs to the whole class. The expert, a professional interior designer specialized in lamp and light designing, was present in the classroom; the interaction between him and the students varied from face-to-face discussions with the whole class, to small team conversations, and to the sharing of comments through the Knowledge Forum database.

Data Collection and Methods of Data Analysis

The lamp designing process was video recorded almost entirely, producing about 16 hours of video material from a single camera. During whole-class activities we recorded the designer’s activities, and during small-team
activities we followed three student teams. For the present study, we selected a team of three girls, whose design process we were able to follow from the very beginning to the end. We selected the peer collaboration episodes of the team and the episodes where they were interacting with the designer.

The analysis was performed at three levels. Firstly, in order to form an overall view of the project, we divided all the selected episodes into five-minute-units \( (f=76) \) and defined the main focus of design activity in each unit. The development of the classification schema was a combination of theory-based and data-driven analysis. The schema was created on the basis of a) preliminary analysis of the video data, and b) reflection on the data in relation to the theoretical framework of our study. This assisted in identifying the relevant aspects of the phenomena in question (Seale, 2006), and produced the following eight categories: 1) ideation, 2) defining constraints, 3) elaborating ideas, 4) making drawings, 5) constructing prototype, 6) making poster, 7) process organizing, and 8) off-task activity.

Secondly, on the basis of identifying the main foci of activities, we selected approximately 34 minute episode from sessions 2 and 3. This episode was from the beginning of the team’s work, and included ideation, idea elaboration, and defining constraints. This episode was interesting, because the design task was still very open and required a great deal of idea generating and negotiating from the team. In order to analyze the nature of interaction within the team, we identified the discourse move of each statement \( (f=650) \). We defined whether the speaker was: 1) initiating, 2) accepting, 3) disagreeing, 4) rejecting, 5) elaborating own idea, 6) building on other’s idea, 7) asking clarification, or 8) discussing off-task issues. We used Barron’s (2000) categorization of response types as a basis for analysis, and complemented the schema with our own data-driven categories.

Thirdly, we examined how the participants used tools, design representations, and gestures to support their verbal communication. Each statement from the selected episode was coded according to its speaker’s use of 1) sketching tools, 2) shared view, 3) pointing (at sketches or other tools), or 4) hand gestures (to describe shape, size, etc.). In the further sections of the present paper, these are jointly referred to as tools.

In order to visualize our data, we created CORDTRA diagrams from the analysis of the statements. Our CORDTRA diagram contains a timeline where the discourse moves and the tools being used are plotted in parallel, enabling their juxtaposing for understanding the nature of the collaborative design process. (cf. Hmelo-Silver, 2003; Hmelo-Silver, Chernobilsky, & Jordan, 2008).

Results

Overview of the Collaborative Design Process

The whole lamp designing process consisted of 11 design sessions during a period of two months. The sessions included the designer’s presentations (sessions 1, 5, 6, and 10) students’ presentations (2, 6, 7, and 11), and designing in small teams. The team selected for the present study worked on their lamp design from the second to the tenth session, altogether approximately 6.5 hours. The time they used per session varied from 15 to 90 minutes, depending on the class schedule and other activities (such as the presentations) during the sessions.

The team started by creating and sketching several design ideas, and developing some of these ideas further (Figure 1). The final idea was chosen during session 3, and elaborated throughout the process. The team also made several drawings of their design, from hazy sketches to blueprints on scale 1:1. The most time consuming activity was the construction of the prototype \( (f=90 \text{ min}, 23.7\%) \), the team built their lamp model from paper, wire, masking tape, and copper pipe during sessions 6, 7, and 8. Making the poster representing their design process and the final product also required a great deal of the team’s time \( (f=75 \text{ min}, 19.7\%) \). The distribution of the team’s various design activities during the sessions are presented in Figure 1.

The students were guided to consider the important constraints for lamp designing. The general constraints were presented by the designer and worked on during whole-class discussions; the more specific constraints were defined by each team with support from the designer. In Figure 1 the constraints are visible only in session 4, although the team selected for the present study considered the constraints on several occasions throughout the design process. However, these sequences were in most cases so short, that they were deluged with other design activities in our analysis of the main activity in each five-minute-unit of the design process. It is, in fact, typical, especially for novice designers, to consider the design constraints in short sequences (Seitamaa-Hakkarainen & Hakkarainen, 2001).

The participants of the team, Emma, Leila, and Nina worked together well, and their design process proceeded rather smoothly. The distribution of statements was quite equal, Leila \( (f=229, 36.5\%) \) and Nina \( (f=234, 37.3\%) \) made almost same amount of statements, Emma \( (f=164, 26.2\%) \) a little less. A closer look to the nature of their discourse revealed that the girls’ had different roles within the team (Figure 2), and this had an effect on their design process.

Nina was the most dominant one, she made many initiatives and many of her statements elaborated her own ideas. Emma was the most silent of the girls, she made fewer initiatives and elaborated them less than the other two. Many of her ideas were disagreed with or completely rejected by Nina and Leila. However, many of
Emma’s statements built on the other girls’ ideas, developing them further. Also Leila built on others’ ideas a lot, and she also made most of the initiatives as well as asked clarifying questions.

![Figure 1](image1.png)

*Figure 1. Main focus of activities of the selected team during the design sessions*

Unfolding Collaboration and Mediation

As noted by Hmelo-Silver and her colleagues (2008), the frequencies provide one view of the collaborative design process, “but they neither provide a sense of chronology nor inform the researchers about particular qualitative features of the discourse” (p. 420). In order to examine how the different aspects of discourse relate to each other, and to the use of different design tools, we created a CORDTRA diagram from the first 34 minutes of the team’s work (Figure 3). At the bottom of the diagram, there is a running count of the statements. The vertical axis shows the categories of participants (1-3 at the bottom), discourse moves (4-12 in the middle), and tools (13-16 at the top). The patterns of interaction, i.e., the speaker, the discourse move, and tools of each statement, are arranged on the horizontal axis in chronological order.

During the first approximately 400 statements the team was generating design ideas, altogether 17 different ideas for a lamp. At first, their designing was mostly horizontal (Seitamaa-Hakkarainen & Hakkarainen, 2000/2004; see also Goel, 1995), they created one idea after another, without elaborating on them much further. Idea number seven, “The Lamp with Hundred Strings” (statements #44-114) was the first vertically developed idea, which indicated that the idea was provisionally accepted (see Al-Doy & Evans, 2011). This idea was initiated by Nina, and she also spontaneously started using sketching (#51) to support her verbal explanation.
Figure 3. The selected team’s first 650 statements of peer collaboration.
Compared to the previous six design ideas altogether, this sequence contained almost a double amount of statements. Nina elaborated her idea verbally and visually, and both Leila and Emma built on her ideas. In addition, Leila asked Nina to clarify several features of the design. No off-task talk occurred during the sequence. Finally the idea was jointly rejected, because of difficulties in working out the technical solutions.

After “The Lamp with Hundred Strings” sequence the team used sketching throughout the episode. From statement #135 onwards, and after the teacher had reminded them, they also used the shared view (i.e., the teacher’s computer screen shared through a data projector) to support their designing. On the screen was the designer’s note from the KF “Lamp Designing” view. He had listed questions to be considered while generating the design ideas, for example, the purpose of the lamp and users’ needs. When the team was discussing the second vertically developed idea, “The Disco Lamp” (idea number 10, statements #159-243), they first talked enthusiastically over the color of the light bulbs and the material of the shade. The designer's questions on the shared view helped them to focus their attention also beyond the superficial aspects (e.g., appearance) that novice designers tend to concentrate on. They considered where the lamp could be used, who would use it, and how well it would light up the area. In the end, the idea was jointly rejected, because the team agreed that there is no real need for their disco lamp.

The final idea started to take shape around statement #378, when Nina presented an idea for a pendant lamp and Leila immediately showed her interest by asking clarifying questions and building on the idea:

Extract 1. The idea of a pendant lamp
378 Nina (showing her sketch): Ha ha, this kind, like this way around, like from Leila’s direction, this is hanging from the ceiling.
379 Leila: Oh, so is it the wrong way around?
380 Nina: Yeah so this is hanging from the roof.
381 Leila: So how does the light then there, come from there?
382 Nina: It reflects off that.
383 Leila: So where is the lamp again?
384 Nina: Inside there. You could make a hole here, and then it comes from here.
385 Emma: Maybe not.
386 Nina: Yeah.
387 Leila (sketching): Ha-ha, hey I know, wait, we’re doing now, doing these chain things, like this.
388 Nina: A hole like that.
389 Leila: Look, now, this kind that’s on both sides, because it comes from up there.

Nina was not so interested in her own idea and she moved on to the next idea, but Leila continued developing and sketching the idea of the pendant. She was eager to reach the decision about the final idea and kept pushing Nina and Emma to make the decision with her by asking repeatedly where and what for the lamp would be used. Finally Leila's attempts succeeded and the team made a decision that the lamp would be used over a dining table. While discussing, Nina was still sketching new ideas:

Extract 2. Reaching decision
437 Leila: Yeah, yeah, so, let’s make it, um, what’s the lamp, what’s it needed for? For the living room or kitchen or where?
438 Emma: It could fit into the kitchen, but it doesn’t really, because it doesn’t produce much light and anyway you need quite a lot in the kitchen.
439 Leila: The dining room.
440 Emma: Dining room?
441 Leila: Yeah, on top of the table.
442 Emma: Maybe.
443 Nina (sketching): Well that’s what I meant.
444 Leila: Oh but you said, you said the kitchen.
445 Emma: So that there’s a table there, that’s how it hangs off there tsiu.
446 Nina: Look I invented a new lamp.
447 Leila: Well try to decide which one we are using.
448 Nina: No but I invented a new lamp.
449 Emma: Why couldn’t this one also have squares?
450 Leila: Yeah I’m just drawing it.
451 Nina: It doesn’t fit. Laura look, I made a good one, Laura.
452 Leila: Wait, what do you mean squares don’t fit this one?
453 Nina: You don’t know how to do it, it’s like this, oho, me neither. This doesn’t fit here at all.
454 Leila: Yes it does.
455 Nina: Look, isn’t it beautiful?
456 Leila: Yeah! That’s how it could be.

Through Nina's sketching, Leila's clarifying questions and repeated requests to consider the needs for the lamp, and Emma’s idea to include squares on the shade (an idea presented previously) the final idea was finally jointly reached. After this the idea started to develop rapidly, the team elaborated the idea through active discussion and sketching. They made decisions concerning, for example, the shape and coloring alternatives of the shade. They stayed mostly on the composition space, but time to time shifted also to the construction space (Seittamaa-Hakkarainen & Hakkarainen, 2001), and considered, for instance, how many light bulbs would be needed and how these should be positioned inside the shape.
Discussion

Designing puts emphasis on conceiving something new and clarifying as yet unknown details. “Design is not description of what is, it is exploration of what might be” (Edmonds et al., 1994, p. 43). That requires active knowledge creation and meaning making - aspects which make D&T settings potentially rich environments for successful learning. In addition, a central aspect of the design process is to conceptualize and visualize an idea of the emerging product (Goel, 1995; Lawson, 1997). Externalization and visualization helps intangible ideas to become concrete and allows them to be generated, modified and transmitted between people. Our previous studies (Kangas, Seitamaa-Hakkarainen, & Hakkarainen, 2011a; 2011b) provided evidence on the crucial role of the designer’s participation and guidance during the lamp designing process. The present study sheds more light on the importance of simulating professional practices in D&T education. Unfolding peer collaboration of one student design team revealed that the lamp designing process included many activities which are not common in D&T education at elementary level, but which are widely used by design experts.

First of all, the design ideas were generated and developed collaboratively. Our analysis revealed that the participants had different roles within the team, and this had an effect on their design process. One of the students was slightly dominating, while one student’s ideas were sometimes disagreed with or completely rejected. However, she still continued to contribute by building on the other girls’ ideas. Thus, the collaborative design process in the team was impacted by the students’ willingness to listen to other’s ideas, to take risks and to share their ideas with others. It appears to us that in the beginning of the process the participants were still working out their roles within the team. During conversation, they were attending to each others’ understandings of the issues, while simultaneously settling social relationships (see also Rowell, 2002).

Second, the process was long, much longer than most design processes that are carried through in schools. The lamp designing process lasted 11 sessions during a period of two months; from these sessions nine were mainly dedicated to the students’ idea generation and elaboration. Although construction of the prototype and making the poster required a great deal of time, also the ideation phase was long. The team selected for the present study produced 17 different design ideas before choosing the one to be developed further. This was possible, because they had enough time to both generate their ideas as well as develop the flow of togetherness. They were able to establish ‘contact zones’ in which talk and tools were used to mediate the emerging design work. However, she still continued to contribute by building on the other girls’ ideas. Thus, the collaborative design process in the team was impacted by the students’ willingness to listen to other’s ideas, to take risks and to share their ideas with others. It appears to us that in the beginning of the process the participants were still working out their roles within the team. During conversation, they were attending to each others’ understandings of the issues, while simultaneously settling social relationships (see also Rowell, 2002).

Third, both horizontal and vertical ideation occurred during the process, which is not typical for novice designers (Seitamaa-Hakkarainen & Hakkarainen, 2001). This might be the consequence of two conditions: the long ideation phase, and the requirement of producing numerous sketches before moving to three-dimensional modeling (cf. Welch, 1998, 2000). Sketches are valuable because they are rich in suggestions of what might be. A sketch is constructed as an arrangement of preconceived objects in a particular relationship, thus, it is a reflection of the meaning of these objects. Emergence results in the perception of new shapes that were not intended to be represented in the sketch (Edmonds et al., 1994).

Finally, with the designer’s support, the young students were able to consider many important constraints related to lamp designing. They, for example, rejected ideas if there was no real need for the lamp. In their final idea they considered where and what for the lamp could be used, what kind of light would be needed, how the positioning of the lamp could be adjusted, and many other constraints that determined their lamp design. These are far beyond the superficial aspects of designing that novice designers tend to concentrate on. This indicates that the lamp designing process was also a successful, collaborative learning process. When analyzing design learning, it is important to evaluate the process and construction of the designs. Designing challenges students to think in new ways and take risks. The open-ended and complex design tasks require focusing on harnessing that engagement, and supporting students as they propose ideas, fail, and propose again. In the present study, the young students were able to develop a design, where various constraints determining lamp and light designing were taken into account. This was accomplished through repeated cycles of designing, and by simulating many professional design practices.

References


