Expert Participation in Elementary Students' Collaborative Design Process

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Abstract: The main goal of the present study was to provide insights into how disciplinary expertise might be infused into Design & Technology classrooms and how authentic processes based on professional design practices might be constructed. We describe elementary students' collaborative lamp designing process, where the leadership was provided by a professional designer. The video-recorded lessons on lamp designing and the *Lamp Designing* view of the project's database constituted the data sources of the study. The results indicate that the designer's participation opened up the world of designing for the students. This enabled the students to engage in embodied design practices, and to gain new insights of the professional mechanisms of designing. Having the professional designer working with them, provided students with the opportunity to gain the full potential that solving complex design problems can offer to learning.

Introduction

This study explores the opportunities afforded by the participation of a professional design expert in elementary students' collaborative design process in context of a broader study project, extending across three semesters. We employ an approach to learning in which design is an integral part of inquiry-oriented knowledge building pedagogy (Fortus et al., 2004; Kolodner et al., 2003; Scardamalia & Bereiter, 2006). Our main goal is to provide insights into how disciplinary expertise might be infused into Design and Technology (D&T) classrooms and how authentic processes based on professional design practices might be constructed. Focusing on the socio-cultural approach, particularly to the research of collaborative learning, we will draw attention to the *participatory learning* and *knowledge-creation* aspects of design learning (Hakkarainen, Palonen, Paavola, & Lehtinen, 2004). Participatory learning (Jurow, Hall, & Ma, 2008) means that learning involves external domain experts working with students in the setting to bridge between school practices and community practices.

Design activities provide students important opportunities to work with complex design tasks within authentic and meaningful learning contexts. Design problems are characteristically ill-defined, dynamic, authentic, and complex; they require integration of knowledge across domains, as well as implementation of conceptual ideas in design of materially embodied artifacts (Cross 2004; Murphy & Hennessy, 2001).The characteristics of the cyclical design process and the complex nature design problems also pose some challenges for design-based teaching; we need to understand how to lead and scaffold design based activities. Teachers may not have deep understanding of the embodied nature of designing, and therefore, may not be able to adequately coach design learning. Design-based activity is seen to be an effective means for dealing with the integrated application of disciplinary skills and content (Fortus et al., 2004), but mastering materially embodied aspects of the process requires access to the instruments and practices of professional designers.

Research into cognitive scaffolding (Wood, Bruner, & Ross, 1976) has indicated that, when provided with external, supporting tools, structures, and real-time guidance, students can be helped to succeed in cognitive processes, that are otherwise impossible. Such observations have encouraged investigators to analyze collaborative learning processes, as well as to develop software-based scaffolds (Quintana et al., 2004). Methods that emphasize the apprenticeship approach to learning offer students opportunities to observe, engage in, and create or discover expert practices in context. These methods are based on verbal scaffolding as well as observation of the performance; modes which are also very typical in D&T education.

The non-verbal forms of scaffolding are crucial in D&T contexts. Gestures, such as pointing, and referring to objects/artifacts and tools, support and guide the design process along the verbal scaffolding (Murphy & Hennessy, 2001). When participants of a design process are examined as beings embodied in socio-material worlds, the importance of the non-verbal, manipulative and practical scaffolding becomes apparent. The material aspect of scaffolding is embedded in technological tools, physical artifacts, activity structures, and shared knowledge practices incorporated in learning processes (Pea, 2004). In the context of D&T, the interaction with tools, concrete objects and materials is a central aspect and offers potentially supportive environment for vital collaborative designing i.e., for developing shared objects and understanding (Murphy & Hennessy, 2001). In the design process, 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. The design process involves parallel working through conceptual reflection and material implementation.

Consequently, in D&T settings material artifacts and tools have a central role in mediating the learning and scaffolding processes.

The involvement of professionals in education has been recommended in several studies, however, relatively little is known about interactive processes of integrating domain experts in inquiry-oriented classrooms. The central idea of the present study was to describe pedagogical practices that allow one to acknowledge the role of domain expert's participation in design learning. Hence, the following specific research questions were addressed:

1) How was disciplinary expertise infused in elementary students' collaborative design process?
2) What was the role of social and material scaffolds in implementing the authentic practices of professional designing?

Method

The present study reports an effort to bridge school and professional life by bringing a design expert to the classroom to guide elementary students through a lamp designing process. The lamp designing was a part of a longitudinal study project, "The Artifact Project", where the aim was to break boundaries of traditional schoolwork by fostering students' inquiring and designing with the help of various experts (for detailed description of the project, see Seitamaa-Hakkarainen, Viilo, & Hakkarainen, 2010).

Participants and the Setting of the Study

The Artifact project was organized in an elementary school, located in a middle-class suburb of Helsinki, Finland. In total, 32 students (19 girls), aged 10–11 years old, participated in the project; out of these, 7 students had linguistic or other educational problems. The focus of the present study, the lamp designing stage, took place in spring 2004 and lasted 11 sessions (one session was 45–135 minutes, depending on the class schedule) during a period of two months. 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 whole-class discussions, to small team conversations, and to sharing of comments through the Knowledge Forum database. The lamp designing process was followed 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 technical infrastructure of the project was provided by Knowledge Forum (KF, Scardamalia & Bereiter, 2006).

Data Collection and Methods of Data Analysis

Our investigation within the Artifact project relies on extensive video recordings of classroom practices. For the present study, we selected all the lamp designing episodes where the designer interacted either with the whole class or with the small teams. In addition, we selected the small-team episodes before and after the interaction with the designer, in order to analyze how the designer's support was taken up by the students. These episodes were further segmented into smaller *design events* (*f*=161)*, each distinguishable from the others on the basis of the noticeably different content or context (Chi, 1997). The length of the events varied from few minutes to over 15 minutes. One event was a coherent whole, beginning from the point where the designer started interacting with the students, and ending when their interaction was drawn to an end and something else (like peer collaboration) begun. For example, the designer's interaction with one team on some particular issue was identified as one design event. Besides the video material, we also analyzed the notes and annotations in the KF "Lamp Designing" view. The analysis on both the video material and the database was performed with some standard procedures of qualitative content analysis (Chi, 1997) with the help of ATLAS/ti software.

The analysis was conducted at four different levels. First, we identified four distinctive social settings in the classroom during the lamp designing process: the designer's presentations, the students' presentations, whole-class discussions, and designing in small teams. Second, the design inquiry phase of the process was determined in accordance to the *Learning by Collaborative Designing* model (LCD, Seitamaa-Hakkarainen et al., 2010): 1) creating the design context, 2) defining the design task and constraints, 3) creating and elaborating design ideas, 4) experimenting and testing design ideas (sketching and prototyping), 5) evaluating design ideas, constraints, and process, and 6) distributing expertise.

Third, we identified the obstacles that the students faced in the various phases of the design process, and fourth, the scaffolding activities (including both social and material scaffolds) that the designer used to support overcoming these obstacles (cf. Quintana et al., 2004). A data-driven approach to categorizing both the obstacles and the scaffolding activities was employed, producing the following six main categories of scaffolding. The designer 1) *provided domain knowledge and own experience* of the design process, and 2) *provided structure for the design tasks*. He also 3) *supported externalization and envisioning of design ideas*, 4) *facilitated idea elaboration*, and 5) *supported professional techniques of external representation*. In addition, the designer 6) *facilitated reflection and evaluation during designing*. Each of these was further segmented into several specific scaffolding strategies, which are presented in table 1. Two independent coders classified

approximately 15% of the designer's scaffolding activities, resulting an inter-rater reliability of .88, which was considered satisfactory.

Results and Discussion

Table 1 provides a general view of the different aspects of the lamp designing process; related to the social setting in the classroom, the design inquiry phase, and the designer's scaffolding activities. The creation of the design context and the definition of the design task took place mainly during the designer's presentations and the whole-class discussions following the presentations. The designer brought his own experience and knowledge of the design process to the classroom, opening up the world of designing for the students. This promoted the collaborative creation of meaningful and authentic design context and task, i.e. the foundations for students' idea generation.

Table 1: Social settings, design inquiry phases, and the designer's scaffolding activities during the lamp designing process.

Social Setting	Design Inquiry Phases	Designer's Scaffolding Activities
Designer's presentations, whole-class discussions	Creating design context	**Providing domain knowledge and own experience** • Making tacit design knowledge accessible • Anchoring information with common experiences
	Defining design task	**Providing structure for the design task** • Focusing attention on the needs for the design • Identifying the design constraints
Designing in small teams	Creating and elaborating design ideas	**Supporting the externalization and envisioning of design ideas** • Providing professional terms for describing ideas • Providing tools and materials for visualizing ideas • Demonstrating how to use sketches and artifacts for visualizing **Facilitating idea elaboration** • Focusing attention on aspects that need elaboration • Providing domain knowledge/language/tools to support elaboration • Modeling alternative solutions
	Experimenting and testing design ideas (sketching and prototyping)	**Supporting professional techniques of external representation** • Guiding to use real measurements while sketching/prototyping • Providing tools/material for sketching/prototyping • Providing hands-on support for handling tools and materials
Students' presentations, whole-class discussions	Evaluating design ideas, process, and product Distributing expertise	**Facilitating reflection and evaluation during designing** • Identifying the design knowledge that students may possess • Providing questions and comments that support explicating knowledge • Summarizing central knowledge • Inviting others to evaluate knowledge

The main activities of the student teams were creating, elaborating, experimenting, and testing design ideas by sketching, drawing, and building prototypes or models. Envisioning the not-yet-existent lamps appeared to be difficult for the students and required both social and physical scaffolding. For example, Ann and Natalie were designing a pendant lamp and had a hard time imagining their lamp from different angles. The designer was busy with other teams and only explained briefly that they have to draw the side view and the cross section of their lamp. The girls did not completely understand these instructions and ended up drawing a picture with a view from more than one angle. Then the designer and the teacher improvised a demonstration with paper cups and the team's drawing (Figure 1).

Figure 1. The Designer and the Teacher Demonstrate How to Visualize a Lamp from Different Angles.

Simple physical scaffolds, such as paper cups and drawings were central to the teams' understanding; the demonstration helped the girls not only to realize the side view of their pendant, but also gain the knowledge of how to envision the lamp from different angles. For expert designers this is basic knowledge, but novices have to learn how it is possible to envision in detail something only imagined, that does not yet exist. Scaffolds helped the students to compensate for the "bootstrapping problem" of mastering rich domain knowledge that they do not yet have; it transformed the tasks and at the same time helped students to build more knowledge for future use (Quintana et al., 2004). The use of material scaffolds revealed the fundamental role of materially embodied processes in design activity.

The students had used Knowledge Forum extensively during previous phases of the project, but it was a new tool for the designer, so it was mainly the teacher who suggested and instructed KF use. She introduced KF' s various aspects to the designer, instructed him how to use them, and used shared view (i.e., the teacher's computer screen shared through the data projector) to support participants' reflection. However, KF was in this phase primarily used as a tool for storing and sharing designs, rather than serving as a genuine discursive knowledge building environment. The students mainly wrote notes after face-to-face activities, iterating and saving the ideas already discussed. The teams produced an average of 7 notes (total 93) and the mean note-reading activity was 22,7%, which was considered rather low database activity. The designer wrote four notes and the teacher two. In addition, the designer wrote 16 annotations; the majority (f=12, 75%) of them were aimed at helping the students in explicating and sharing their knowledge.

Conclusions

The present investigation reported a longitudinal experiment in which elementary school students appropriated the world of designing under the guidance of a professional designer and the teacher. The aim of the overall project was to engage students in simulating professional practices and building a deeper understanding of the entire design processes, i.e., working with complex design problems, and dealing with different kinds of representations as well as knowledge and constraints related to designing. The development of professional ways of thinking and acting plays an important role in encouraging young people to tackle the creative and technical solutions of the design field. In the present study, the designer's participation opened up the world of designing for the students, helping them to appropriate the basic tools and practices of professional designing. This allowed the students to engage in productive design processes and to gain new insights into the processes and mechanisms of designing. Furthermore, having the professional designer working with the students

provided students with the opportunity to gain the full potential that solving complex design problems can offer; the potential is related to the inherently embodied nature of design learning.

Designing is not mere practical activity for straightforwardly implementing conceptual ideas in practice. For one thing, validation of conceptual knowledge in materially embodied practice makes design a worthwhile cognitive and intellectual experience. The process of iteratively designing and constructing materially embodied artifacts is, in itself, a multi-modal process in which conceptual, practical, and materially embodied activities cross-fertilize and support one another. In the present study, the students were very much working with imagined and envisioned objects, along with actual artifacts. Although the students were guided to utilize various external representations, working with the imagined lamps was very hard for them (cf. Fortus et al., 2004). The various design artifacts that the designer brought into the classroom (e.g., photos, lamps) and the artifacts that the students created in the course of their designing (e.g., sketches, drawings, models) carried the tacit working knowledge of designing, enabling the inexperienced students to pursue genuine design inquiry. The actual implementation of ideas in design of materially embodied but knowledge-laden artifacts offers unique opportunities for learning. Dealing with concrete materials offers probes which evoke novel possibilities of, for example, learning spatial, functional, and aesthetic aspects. More generally, the analysis of the process promises to give a different and valuable perspective on goal directed, embodied and material cognitive activities which aim at a practically adequate outcome.

The shared KF view was actively used as the collective memory of the community throughout the sessions. Through the shared view, both the students' and designer's knowledge was constantly available to viewing by all the participants, promoting collaborative design thinking. Accordingly, the point was not to focus on producing a large number of textual notes to KF database but participate in actual design of materially embodied artifacts. In this regard, KF provided a shared working space that assisted in documenting various aspects of the process and mediating classroom activities in many ways.

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