Mapping Ideas Around the Table

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ABSTRACT

This paper reports work in progress regarding the design, development and evaluation of a surface computing application in support of collaborative problem-based learning (PBL). The domain-independent application, so called *Ideas Mapping*, supports idea generation, collaborative decision making and group artifact construction – all of which are important aspects of collaborative PBL. During idea generation, *Ideas Mapping* replicates physical post-it notes on a multi-touch tabletop. Additional functionality supports student collaboration and interaction around the organization of ideas into thematic categories associated with the problem at hand. We report on the functionality of the application which was designed and developed following a user-centered approach. We also report preliminary results from a case study conducted to examine the affordances of the application for collaborative PBL.

Categories and Subject Descriptors

K.3.1 Computer Uses in Education: Collaborative learning

General Terms

Design, Human Factors

Keywords

CSCL, CSCW, collaborative learning, surface computing, multitouch interactive tabletops, collaborative PBL, interaction design

1. INTRODUCTION

Our overarching goal in this work is to advance the current practice of *collaborative* problem-based learning (*PBL*) in the university classroom through the use of innovative technology, allowing students to engage in active collaboration, fertile discussion, and physical interaction around emerging group artifacts. A multi-touch tabletop surface can support collaboration, allowing different patterns of turn taking, negotiation and interaction. While this innovative technology appears interesting and promising, further development of learning applications is required before it can provide a platform that supports and improves the practice of collaborative PBL in the university classroom. We aim to design, develop and evaluate a set of surface computing applications that are domain-independent, require no training, and can be integrated in a collaborative PBL curriculum. Through user studies and in-class explorations we further seek to assess the impact of surface computing for learning. This paper reports our work in progress in this area.

2. EXISTING KNOWLEDGE

Surface computing and particularly multi-touch interactive tabletops have recently attracted the attention of the Human Computer Interaction (HCI), instructional technology, and Computer Supported Collaborative Learning/Computer Supported Cooperative Work (CSCL/CSCW) communities. A few empirical investigations have demonstrated their affordances for collaborative learning, yet a lot remains to be done. One such investigation is the StoryTable – a surface computing application designed for DiamondTouch to support children's storytelling activity in groups [4]. StoryTable enforced cooperation between children by allowing their simultaneous work on individual parts of the task, while forcing them to perform crucial operations together in order to progress. Another example is SIDES - a surface computing application designed for adolescents with Aspergers Syndrome to practice effective group work [8]. Using a four-player cooperative computer game running on DiamondTouch, adolescents collaborated to build a path by combining individually owned pieces. Moreover, the OurSpace application for DiamondTouch aimed to support children in designing a seating plan for their classroom [5]; the study sought to examine the potential of surface computing to support collaborative design. Finally, recent experiments by [3] with 80 participants working in groups of four showed that the attractiveness of the tabletop device improved subjective experience and increased motivation to engage in the task.

PBL is an instructional approach in which students work collaboratively on authentic, real world problems; it is considered a powerful model that is engaging and leads to sustained and transferable learning [6]. Albion and Gibson [1] contend that because PBL consists of a presentation of authentic problems as a starting point for learning, increased motivation and integration of knowledge by learners occurs. Moreover, Mierson and Parikh [7] found that as learners work collaboratively in groups to find solutions to complex real-world problems, they learn how better to plan and determine what they need to solve problems, pose questions, and figure out where they can get answers to questions as they make sense of the world around them. Overall, effective PBL should apply across various contents and domains, age spans, and directly impact learning outcomes and the effectiveness of learning [6].

Effective PBL requires both the selection of appropriate learning activities as well as the creation of information/learning spaces in which the activities can take place. In this work, we seek to explore surface computing as a means for the creation of learning spaces that support idea generation and fertile discussion of alternative views and motivate collaboration and physical interaction around the construction of group artifacts – all of which are important aspects of collaborative PBL [6]. Overall, it is apparent from our review that very little is done about the use of surface computing for collaborative PBL, while little is known about the added value of surface computing for learning in general.

3. DESIGN METHODOLOGY

We adopted a strongly user-centered approach, emphasizing the engagement of students and instructors in the design process. User-centered design focuses design activity on the user. It takes account of the user by: (a) having a better understanding of the users, who they are, their tasks, expectations, capabilities, limitations, preferences, context of use; (b) involving users in design activities from the outset and having them as active participants where feasible.

Four college students and three instructors (participating stakeholders) were involved contributing to elements of the design. All design and evaluation sessions took place in the Cyprus Interaction Lab (http://blogs.cut.ac.cy/interactionlab). The Cyprus Interaction Lab includes a fully equipped usability lab with one way mirrors and remote controlled cameras. All sessions were video recorded and analyzed.

First, we aimed to better understand how people generally collaborate and discuss ideas around a physical table surface using standard post-it notes. Furthermore, we wanted to inform the analysis of user needs and explore initial design ideas for a surface computing application in support of PBL. Through a low-fidelity paper-based prototype, we simulated a PBL activity with four students around a (turned-off) tabletop using paper and pencil. The PBL scenario involved "the creation of a game industry in Cyprus and the factors involved." First, students generated ideas individually for 10 minutes. They wrote a (physical) post-it note for each new idea. Next, the ideas appeared one-by-one on the table and became subject to discussion, after a brief explanation from their originator, in an effort to categorize them in thematic units. Students revisited and changed ideas, rejected less promising ones, and generated new ideas during a collaborative decision making process leading to their thematic categorization. Finally, the activity concluded with a consensus of the main factors (i.e., resulting thematic categories) involved in the creation of a game industry in Cyprus. The three instructors observed and kept records of the interactions occurring throughout the activity. Finally, all participating stakeholders and two software developers discussed the potential surface computing application and contributed to elements of the design from their points of view.

Following the low-fidelity design discussions and analysis of user needs, a Beta version application was developed in Action Script 3.0, for a widely used multitouch tabletop (TouchMagix, www.touchmagix.com/magixtable/). The application, so called *Ideas Mapping*, was designed to be domain-independent and require no training to allow for easy integration in a collaborative PBL curriculum of any context.

Finally, we involved all participating stakeholders in optimizing and finalizing *Ideas Mapping* through iterative cycles of design, development and evaluation. During these cycles stakeholders participated in different PBL scenarios (e.g., "How can we involve youths in decision making regarding the political and social issues in Cyprus?") using *Ideas Mapping*, while providing feedback and suggesting revisions. In three major iterative cycles we came to a satisfactory solution that all stakeholders endorsed.

3. APPLICATION FUNCTIONALITY

Overall, the technology aims to support students' collaboration and interaction around the organization of ideas into thematic categories (the group artifact) associated with a PBL scenario. The resulting application facilitates collaborative PBL in three stages:

Figure 1: Idea generation using mobile devices

Stage 1: With a PBL scenario at hand, each collaborator generates new ideas for 10 minutes. Ideas are typed into a web application (producing an XML file associated with *Ideas Mapping*) through the use of a mobile device (laptop, tablet pc, cellphone connected to the Internet). The need for the integration of mobile devices and a web application emerged from a constrained imposed by TouchMagix (also true for other platforms such as MS Surface) -- that text entry can be done from one keyboard at a time. For the kind of collaborative PBL we sought, this constrained would be fatal. To resolve this problem, in the Beta version application, we developed four virtual keyboards on the tabletop (one for each user). However, users experienced difficulties typing extended ideas on the particular virtual keyboard; the keyboard interaction suffered from input latency and mistyping issues. Thus, the use of mobile devices for input via a web application was considered as a practical solution to the problem by allowing collaborators to generate digital post-it notes at the same time. This problem demonstrates both the still existing technical limitations of tabletops but also the importance of user input in developing applications for such technologies.

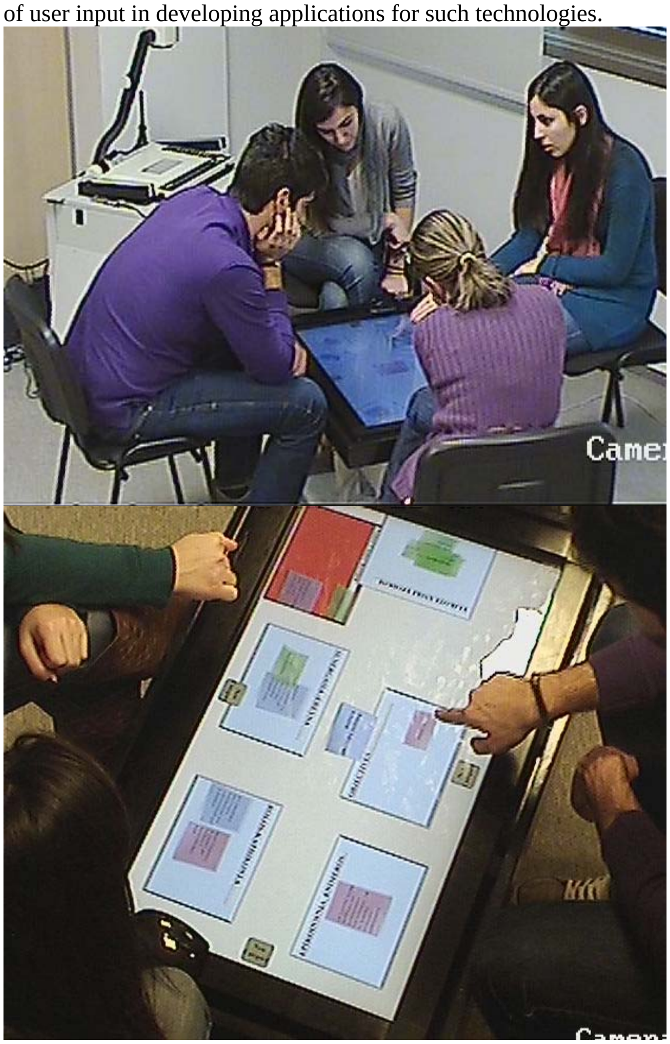

Figure 2: Categorization of ideas it in thematic units

Stage 2: Next, the ideas are presented one-by-one, as digital post-it notes in the middle of the tabletop surface and become subject to discussion amongst the collaborators. For each idea, collaborators make an effort to categorize it in a thematic unit. Collaboration actions -- physical and cognitive -- include:

- Participants may be asked to further explain their ideas to the rest of the group members. In fact, this is encouraged as every post-it note is automatically turned towards the participant who contributed it. This functionality was implemented during the cycles of design-development-evaluation as a result of stakeholders' input.
- Thematic units can be created by any participant using a virtual keyboard. Once a participant begins the categorization of an idea (e.g., either begins to type a thematic unit or simply touches the post-it note), others must wait as only one keyboard is presented at any given time.
- Participants can manipulate post-it notes to move them across the surface, rotate and resize them.
- Ideas can be placed in a "notes to decide later" box to be revisited upon the categorization of other ideas.
- In this stage, participants cannot edit each other's ideas, cannot generate new ideas, and post-its, and generated thematic units cannot be deleted. These design decisions were enforced by all stakeholders as a form of scaffolding during the collaborative activity.

Stage 3: In this last stage, more flexibility is given to the participants to engage in collaborative decision making and reach a consensus on a group artifact - the thematic categories and taxonomy of ideas. In addition to the collaboration acts of stage 2, participants can now rename thematic units, generate new post-it notes (i.e., new ideas), and delete post-its or thematic units as needed. Moreover, ideas can be duplicated and placed in two categories if required -- functionality added based on stakeholders input during the cycles of design-development-evaluation. In practice students in stage 3 revisit and finalize thematic units, release ideas that are less promising, and generate new ideas in a collaborative decision making process leading to a consensus thematic categorization (the group artifact).

Figure 3: Consensus on a group artifact

4. EDUCATIONAL EVALUATION

The affordances of *Ideas Mapping* for collaborative PBL are currently being evaluated through a series of case studies with groups of college students. Below we report preliminary results from our first case study.

Theoretical Framework: Overall, the project is situated in theoretical perspectives that reconceptualize learning as a social activity and knowledge as socially constructed (Basford 200). We are particularly driven by resent work on the development of a theory of small-group interaction in CSCL settings, known as "Group Cognition" [10].

Participants and setting: For the first case study, our four college student-stakeholders were invited back to the finalized surface computing application to engage in a new collaborative PBL activity. The PBL scenario involved the "creation of an action plan that can improve college students' experiences at the Cyprus University of Technology, including social and educational aspects." The session was video recorded for analysis.

Analysis and Preliminary Findings: Video analysis was conducted following an inductive approach; that is, the video corpus was considered with broad research questions in mind. The questions guiding the analysis were: What are the phenomena apparent in the interactions amongst the participants and the use of technology -- what types of discourse and gestures take place around the tabletop? What evidence is present regarding the impact of surface computing in group-cognition in the PBL setting?

One of the researchers considered the video corpus in its entirety - 57 minutes. The video was naturally segmented into three episodes- the three stages of the tabletop application. Most interaction occurred during the 2nd and 3rd episodes, which became the focus of the analysis. The researcher repeatedly watched the 2nd and 3rd episodes, marked video segments of interest, and created transcripts, in an effort to categorize the types of discourse and gestures used by the group members around the tabletop. That is, coding categories were created in a recursive manner. The process was facilitated by NVivo 8.0. (See [9] for a review of video analysis approaches).

A preliminary coding scheme is presented in Table 1. This coding scheme is still under development and will be further refined as more case studies are video analyzed. Ultimately, the coding scheme will help us identify patterns in and across case studies, as well as examine interesting group-cognition phenomena and the added value of surface computing in the collaborative learning process.

Table 1. Preliminary Coding Scheme

- Information Sharing – Defining/describing/identifying the problem
- Proposing – Proposing a thematic unit/new idea
- Elaborating – Building on previous statements, Clarifying
- Negotiating meaning – Evaluation of proposal, Questioning/ answering, Expressing agreement/disagreement, Providing arguments for/against
- Stating consensus – Summarizing ideas, Metacognitive reflections
- Other talk – Tool-related talk, Social talk, Laughter
- Communicative Gestures – Show on the table without touching, Dominating/blocking gestures
- Touch Gestures – Resize, Rotate, Type, Move something across, Random touching or touching to explore

To close, this paper reports our work in progress regarding the design, development and evaluation of a surface computing application in support of collaborative PBL. At the very least, we have evidence that the CSCL setting of the study encouraged and stimulated discussion -- with a problem at hand and a multi-touch tabletop application to support them, the four college student-participants engaged in 57 minutes interaction containing cognitive and physical elements.

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