# USE OF A MULTI-TOUCH SURFACE TO SUPPORT DISTRIBUTED DESIGN MEETINGS AS PART OF A PROBLEM-BASED LEARNING APPROACH TO TEACHING DESIGN

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**ABSTRACT**
In today's globalized economy, students of engineering and product design need to acquire the skills to work as part of distributed design teams. Students on the European Global Product Realisation (EGPR) course follow a problem-based learning approach to develop such skills by working together in design teams where members are distributed across 5 different countries in Europe. This work is currently supported by the use of various different technologies. However, communication between team members remains a major challenge, especially during the design phase of a project. This paper reports the results of an exploratory study in which students in distributed locations worked together on sketching a mobile user interface design using a multi-touch interactive surface in combination with software to support synchronous on-line communications between distributed team members. Results suggest that the novel combination of technologies investigated in our study provides interesting opportunities for teaching in this context. However, the support provided by the particular combination of tools adopted in this study was in some respects limited. We end with some recommendations for future development that will address these limitations.

*Keywords: Distributed design teams, interactive surface, teaching design*

## 1 INTRODUCTION

There is an increasing trend towards the use of global design and development teams, whose members may be drawn from a number of different countries around the world. As explained by Daily et a [1] 'Worldwide-distributed design … offers the potential for increased cost savings, reduced time to market, and improved efficiency. It also has the potential to improve the design process by enabling wider expertise to be incorporated in design reviews, reducing the need for travel, and further reducing dependence on physical models.' This means that students of engineering and product design need to acquire the skills necessary to work as part of a distributed design team.

A common approach to teaching design of various kinds is to use problem-based learning, where students are set a design task in a real or imagined scenario and need to develop a solution. This method is considered to be optimal for the development of the design competences that are seen to be essential in modern engineering education [2,3]. Problem-based learning is the approach adopted in the European Global Product Realisation (EGPR) course at [removed to preserve anonymity], which involves students working together in design teams where members are drawn from 5 different universities from the UK, the Netherlands, Slovenia, Croatia and Switzerland. This course is designed to increase knowledge and skills through engineering education and to develop students' competences for industrial collaboration and realization in the context of geographically distributed teams.

In the EGPR course, students work together to collaboratively design a solution to a problem proposed by an industrial partner. Unlike the traditional courses in engineering, students in EGPR are asked to fulfil not only tasks of market analysis, product definition, product conceptualization and detailed design, but also the virtual and physical prototyping of a global product in the distributed design environment. Problems in recent years have included a mechanical device for carrying heavy loads up the stairs, design of point-of-presence stands for male cosmetics products, and the design of a green, ecological holiday home. Students form international groups of up to 8 students from at least 3 countries. The entire research and design phases of the project are done without students physically meeting each other.

Thus students undertaking the EGPR course gain experience not only in product design, but also in collaborating with colleagues in remote locations to work on a common design problem. To date, students on this course have typically communicated by: (1) sharing files using modern educational content management systems; (2) using the Internet to set up group meetings using various voice and video applications. In addition to this, a video conferencing system is used for lectures and larger group meetings.

There are three main user groups are involved in the EGPR course, namely students, academic staff and the industrial partner. Communication has been identified by two of these groups, the EGPR students and instructors, as a major challenge [4]. This is especially the case at the design phase of the project, when student groups meet often to discuss various designs and choose the best design to present to the industrial partner and the course instructors. Lack of real-time interactive tools for cooperative design has been identified in the past as a key communication challenge.

In the study reported here, our aim was to investigate the use of a multi-touch interactive surface in combination with software to support synchronous on-line communications between distributed team members as a potential environment for use by the students in this context.

In the rest of this paper, we first present an overview of the literature in relation to computer-based creativity support tools (see section 2). We then describe our study (section 3) and present an analysis of the results (section 4) in relation to some of the requirements and constraints identified earlier in the paper. We end with conclusions, suggestions and recommendations for future work

## 2 BACKGROUND

A number of authors have identified requirements and principles for the design of computer-based tools to support creativity, and creative design. First, according to Schon [5], such tools must support a language of design that includes *drawing* and *talking*: drawing to enable experimental sketching, and talking to enable reflection. Another important concept in relation to creative processes is the notion of *flow*, where people are enjoying, are fully immersed in and focused on nothing but the activity in hand [6]. According to Shneiderman [7], the challenge in developing computer-based creativity support tools is to 'preserve appropriate elements of existing … [creative practice] while shaping new technologies and then integrating them into the workplace'. Thus in order to support creative thinking, a tool must be so easy to use that it does not distract its users or disturb the flow of their creative thinking, but rather fades into the background, so that users are almost unaware that they are using it.

Many of the tools discussed in relation to supporting co-located collaborative creativity involve the use of large, shared, interactive surfaces that groups of designers can work around together, collaboratively manipulating shared design representations. For example, the i-Land environment provides large custom-built interactive surfaces for collaborative group work [8], and in the EDC environment described by Arias et al [9], designers work around a horizontal electronic whiteboard interacting with computer simulations in order to do urban planning. Of course, providing computer-based support for design teams whose members are working in different locations is more challenging still, introducing other requirements in relation to *communication* and '*awareness'* - making sure all group members are aware of what the others are doing [10,11].

Our aim, in the small-scale study reported here, was to investigate the feasibility of using an interactive multi-touch surface, of the kind used to support co-located collaborative design teams, in combination with software designed to support synchronous communication between members of distributed teams.

## 3 EXPLORATORY STUDY

In our study, we wished to explore the feasibility of introducing a multi-touch surface to support collaboration between a number of students at one location and one or more students in a remote location.

### 3.1 Subjects

A total of 20 people participated in the study, including 11 undergraduates, 7 postgraduates, and two academics. Of these, 14 had some previous experience of using an interactive surface of some kind and 6 did not. 17 had already used some form of online communication software (such as Skype, MSN or yahoo messenger), and 3 had not. Participants worked in 5 groups of 3 – 5 people, where one person was always in a remote location, and the rest were working around the interactive surface as described below.

### 3.2 Apparatus

The interactive surface used in this study was the MERL DiamondTouch [12], in combination with a notebook PC (HP dv5), and a data projector (Infocus in10). The tablet PC for the user based in a remote location was a HP Compaq tc4200. The software used to support screen sharing and communication between the two locations was Adobe Connect Pro [13] and Skype [14].

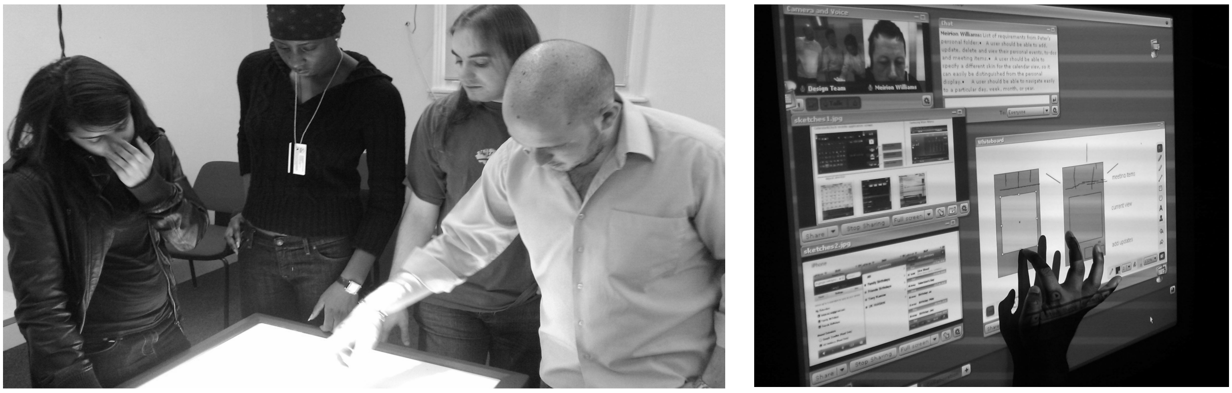

*Figure 1: Participants working around the interactive surface (left), and a view of the Connect software, including whiteboard facility, in use on the interactive surface (right)*

### 3.3 Methods

Participants were asked to imagine that they worked for a global company with teams around the world developing applications for mobile phones. One of the team was to play the part of the design leader wanting to participate in an initial design meeting where he and the rest of the team would sketch out ideas for a new calendar and clock interface. The 'design leader' was asked to share some sketches of similar designs, and requirements for the new design, with the rest of the team, and then to participate in whole group discussion and development of sketches for a new design. Basic functionality of both the interactive surface and the tablet PC were then explained, and participants were given a chance to familiarize themselves with the devices they would be using.

One member of the group was then taken to a room elsewhere in the University, while the rest of the group remained in the room with the interactive surface. Participants were asked to think aloud while they worked.

The task lasted for about 30 minutes, and participants were then asked to complete a questionnaire about their experiences during the study. In the questionnaire, participants were asked to rate a number of statements from 1 – 6 where 1 meant 'strongly agree' and 6 meant 'strongly disagree'. Finally, participants were given a short interview to gather some qualitative feedback.

## 4 RESULTS

The results of our study suggest that the use of a multi-touch surface in the context described above provides both opportunities and challenges as described below.

### 4.1 Support for Design

In this section, we consider the support provided in our study for the basic design activities of drawing, or sketching, and talking as identified by Schon [ref], described above.

#### 4.1.1 Drawing

The quality of the images on the tabletop was rated reasonably highly (average rating for the statement 'I was satisfied with the video quality' was 2.4), though several participants working around the interactive surface noted that the shadowing effect, caused when the projection from the projector above the surface was interrupted by a hand, or by someone leaning over the table, was disruptive.

Manipulation of objects on the screen was sometimes problematic, particularly for those working on the interactive surface, and the average rating for the statement 'I was able effectively to manipulate objects on the screen was 4.2. A particular issue was the fact that sometimes, when participants simply wanted to point to part of the design they were working on, they inadvertently drew on it, meaning that these additional marks then needed to be deleted. Another frustration was that, since the whiteboard application in Connect has not been designed to support multi-touch interaction, only one user at a time could be working on the developing sketches.

Finally, the designs that teams were able to produce appeared rather simple and childish, due to the limitations of the whiteboard feature of the screen-sharing software. The average rating for the statement 'I was able to effectively create objects using the whiteboard' was 3.5, and one participant commented that they would have liked 'a more intuitive and more functional whiteboard'. Finally, it was suggested that it would be more natural to provide a pen for drawing, rather than using a finger directly on the interactive surface.

#### 4.1.2 Talking

The quality of audio in the technical arrangement used was often problematic. The statement 'I was satisfied with the audio quality' was rated, on average, 4.1. This significantly disrupted communication between the participants working around the table and the remote participants on a number of occasions. One participant commented 'Audio quality was poor which had a negative effect on communication within the group'. There were also some problems with the latency of the audio channel.

#### 4.1.3 Flow

Flow was maintained quite well for some of the groups, but in others it was disrupted by problems with the technical configuration, including loss of network connection between the surface and the tablet PC. While many of the participants enjoyed working on the tasks at hand, others were frustrated by these technical difficulties. The statement 'I found getting around and performing tasks effortless' was rated on average 3.4, indicating that participants often had to spend significant effort overcoming challenges of the technical environment, which would therefore have distracted them from the design task at hand.

### 4.2 Support for distributed teams

#### 4.2.1 Communication

The statement 'Communication during the session was good' was rated, on average, 3.4, suggesting that there were some difficulties in this area. Two participants mentioned the importance of agreeing rules, or as one of them put it, 'ceremonial issues', about 'how to interact with other people without offending them in this environment'. Where these broke down, or had never been agreed or understood, there were some conflicts in communication where two people were trying to speak at once, although these were relatively easily fixed (the statement 'It was easy to solve communication conflicts' was rated 2.45 on average).

#### 4.2.2 Awareness

Synchronising actions between different members of the group worked well for much of the time. A good example of this was when the group working around the interactive surface were unable to manipulate an object in the whiteboard, and the remote participant was able to do this for them. However, there were some instances where the remote participants in particular were not able to understand what those working around the surface were doing, maybe because they weren't speaking, or were pointing at parts of the emerging design but not touching the interactive surface (since, as previously mentioned, this would have interfered with the drawing). While the overall average rating for the statement 'I was able to follow the other participants' actions' was 3, for remote participants, the average was 4.7. As one participant commented ‘There should be the ability for the user on the other side to be able to see what we are pointing at’.

## 5 CONCLUSIONS

The scenario under investigation in this paper presents some interesting opportunities for teaching students the skills they will need to participate in distributed design teams in today’s globalized economy. There is clearly the potential for synchronous development of design ideas by designers working in geographically remote locations. However, the support provided by the particular combination of technologies adopted in this study was in some respects limited. These limitations mean that this combination of technologies would not, at present, provide an appropriate environment for problem-based learning of distributed design, where students are already tackling the significant challenges of jointly developing a design with colleagues in remote locations, and will not benefit from the additional challenges introduced by the tools described above.

However, we believe that as technologies such as interactive surfaces improve, and the options for on-line communication increase, a similar arrangement may soon become a more viable option. In future work we will investigate the use of alternative screen-sharing software, such as that now offered by Skype; provide more advanced, pen-based, software for sketching that enables a ‘pointing’ mode as well as a ‘sketching’ mode; make use of true multi-touch interaction during sketching around the interactive surface, increase audio quality by providing headphones and mics for all users; and include a video link that allows participants to see the expressions of others.

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