

## **TEAM COMMUNICATION AND INNOVATIVE DESIGN PRACTICES: THE EFFECT OF TEAM ADOPTION AND IMPLEMENTATION OF THE TABLET PC**

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Today, designers have access to larger amounts of content information and consequently, groups of people working collaboratively can access and communicate information both synchronously and asynchronously. The role of pen-based technologies, and in particular, the tablet PC, has also played an increasingly important role in how designers communicate through external representations. By identifying the specific effects of the tablet PCs on team communication and matching design practices we investigate how technology and communication shape team design practices. It is also important to investigate the degree to which designers adopt and utilize these unique features of the technology. In addition, the impact of attitudes on usage is of important interest, due to its relationship with the adoption and implementation of tablet PC features. Under a previous project, students were assigned into teams based on prior experiences, and tasked with creating an innovative design solution for a client. This study will use the observational data collected from that project, coupled with researcher field notes, focus group interviews, and background questionnaires to investigate if the unique features of Tablet PCs shape team communication and corresponding design practices. In addition, I investigate whether teams' previous experience with technology has an effect on design practice. Initial results show teams who had previous experience with technology are more likely to use specific features of the tablet PC to facilitate communication compared to those with little prior experience in technology. Teams leverage the features of the tablet PC to assist in the design process produced the more innovative design solutions compared to those who use methods that are more traditional.

### **INTRODUCTION**

Today, designers have access to larger amounts of content information and consequently, groups of people working collaboratively can access and communicate information both synchronously and asynchronously. In addition, graphical technologies make it possible for people to interact in multiple ways (Scaife & Rogers, 1996). While pen-based interfaces are more and more prevalent (Long, 2001), pen-based devices are also playing an increasingly important role in many widespread fields including science education (Berque, Bonebright, & Whitesell, 2004) and interaction design (Nam, 2005). The role of pen-based technologies has also played an increasingly important role in how designers communicate through external representations. Yamamoto and Nakakoji (2005) found that not only do external representations influence user decisions, but they also allow users to generate and interact with multiple representations including partial and final representations of the solution. Tablet PCs in particular, are becoming a popular substitute to personal computers and personal digital assistants (PDA) (Bull, Bridgefoot, Corlett, Kiddie, Marianczak, Mistry, Sandle, Sharples, & Williams, 2004). They combine unique features such as high computing power, direct pen-based input, and collaborative software to facilitate communication throughout the design process. Identifying the specific effects of tablet PCs on team communication and matching design practices will provide better insight on how technology shapes team design practices.

### **BACKGROUND**

Successful designers strategically move from conceptual ideas to completed designs, implementing a refined process with certain artifacts and representations playing an important role in supporting innovative ideas, and addressing client needs. This mainly involves the identification of possible solutions and finally, the selection of the optimal one (Hazelrigg, 1998). How designers identify and manipulate possible solutions through communication of external representations, e.g. sketches, is of specific interest due to the important role of sketching in design.

Erickson (1996) defines design as a, "distributed social process, and, as such, communication plays a vital role (p. 32)." Material, cultural, and social dimensions also structure the environment in which design takes place (Lui, Meressian & Stasko 2007). One idea surrounding design, distributed cognition, is based on the premise that cognition occurs not just from the internal thought processes of individuals but also from external representations, such as sketches (Brereton, 2004).

The combination of sketching and physical simulation is ideal, i.e. the coupling of freehand sketching and the analytical abilities of computational tools (Masry & Lipson, 2005). Furthermore, Lawson (1997) claims that, not only is drawing is vital to designers, sketching is an effective means of communication and concept development. While the static nature of paper makes it difficult to support dynamic visual data, the tablet PC offers a more feasible solution by providing a digital ink feature to manipulate and support

dynamic external representations (Ellis & Groth, 2004). While sketching and communicating external representations within the team is a critical part of the design process, it is also important to investigate the degree to which designers adopt and utilize these unique features of the technology. Furthermore, studies found that the tablet PC helps in managing time more efficiently (Simon, Anderson, Hoyer & Su, 2004). There has been extensive research done on the impact of attitudes on technology use. The Theory of Reasoned Action (TRA) (1975) postulated that social surroundings and attitude toward the technology controls behavioral intention to use the technology (Fishbein & Ajzen 1975). In this study, the impact of attitudes on usage is important to acknowledge, because without the adoption of the tablet PC itself, the unique features that facilitate communication throughout the design process are obsolete.

### OBJECTIVE

The purpose of this study was to investigate if the unique features of Tablet PCs shape team communication and the corresponding design practices. In addition, we were interested in whether teams' previous experience with technology has an effect on design practice. This study hypothesized that more technologically experienced teams utilize the collaborative features of the Tablet PC as well as the features that facilitate external representations in order to produce more innovative solutions. Figure 1 illustrates the proposed relationships between the features of the Tablet PC and its influence on design practices.

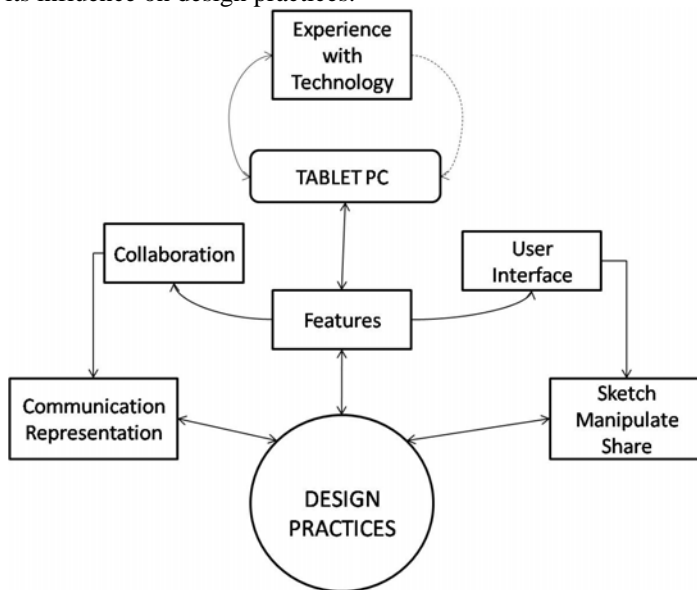


Figure 1. Effects of Tablet PC Features on Team Design Practices

### METHODS

(Note: Data was previously collected under a larger project to study creativity in engineering design.)

### Research Design

A mixed methods approach was used for this study. Initial data on background information was collected through online questionnaires, which included both open-ended and single response questions. Observations during various stages of a design project were made during teams meetings that took place in a designated room on a weekly basis. Within team, e.g. member to member, interactions as well as team interactions with technology were analyzed. Additionally, we collected team and individual design artifacts throughout the process to triangulate with the observational data on how teams utilized both their access to large amounts of information and technological resources.

### Participants

All the participants were freshman-engineering students, part of the fundamental engineering course, which required tablet PCs for all engineering students enrolled in the college. Students were grouped together into teams based on their responses to a background survey. Specifically, students with the highest experience in technology were grouped together. The self-reported average score was approximately 6 for their experience in technology and the students with the highest experiences in design, teamwork, and sustainability were grouped together similarly. Four teams of approximately 4 students each were observed during the various stages of a design project.

### Questionnaires

An online questionnaire was administered to the students to assess their experience with technology, design, teamwork, and sustainability. This questionnaire elicited quantitative data in the form of Likert-type questions and well as qualitative data in the form of open-ended questions. Thus, Likert-type questions asked them to report their experiences with technology, teamwork, and sustainability. Each student self-reported their experience in these four areas from 1 (no experience) to 7 (extensive experience). The open-ended questions were intended to allow users to elaborate on their previous experiences in order to differentiate between levels of experience in technology. For example, students who operated basic DVD players on a daily basis were classified differently from those who did activities such as advanced computer programming or modeling.

### Procedure

As part of the curriculum for the course, freshman-engineering students were required to work with a client on a design project called the 'Sustainable Energy Design Project'. Throughout the course, teams developed innovative solutions to utilize renewable energy sources for a large farm in New Hampshire. The students were involved with an outside client who provided them with information about the available resources and specific design context. The students could also

communicate with the client asking them specific questions throughout the course of the project. Communication between the client and the teams as well as between the different teams was possible through an online Wiki format, where all teams had access to the wiki posts.

Students were prompted to design innovative solutions using sustainable energy ideas by following a series of steps that included writing a research report, brainstorming ideas, sketching, prototyping, and demonstration. Figure 2 illustrates the design process (as defined with respect to the course/ project in this study). For the purpose of this study, an innovative design was defined to be one that was chosen for implementation by the client over the existing practices.

The online-administered background surveys were provided to all the students. Based on previous experience, students were grouped into teams. The teams selected for this research project were provided with an assigned design space/ meeting room where they could convene and discuss design activities. All interactions were documented with audio and video recorders. Upon completion of the project, focus group interviews were conducted with each team. Researchers were also present during all team meeting design session to record observational field notes.

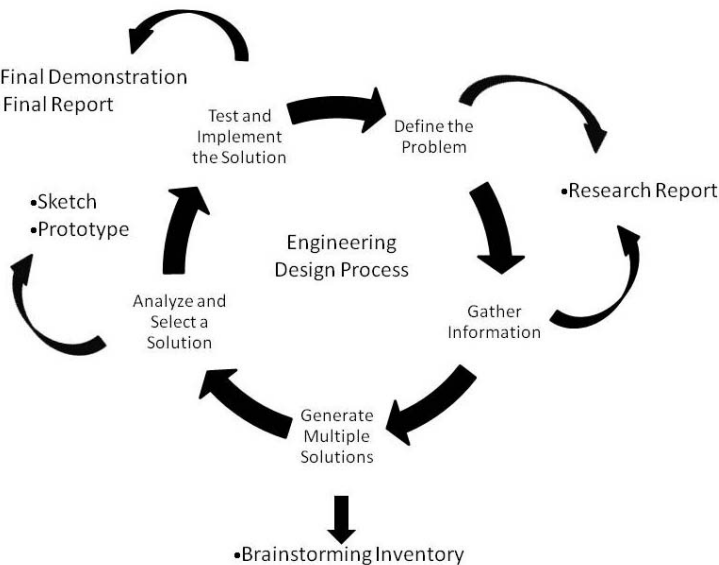


Figure 2. Design Process and Corresponding Artifacts

## DATA ANALYSIS AND RESULTS

The unit of analysis for this study was an individual team as a composite of members and our outcome measure was based on the team's final design solution. The constructed framework for analysis (Figure 3) utilizes the background survey to inform the interactions between team members and technology based team observations and focus group interviews.

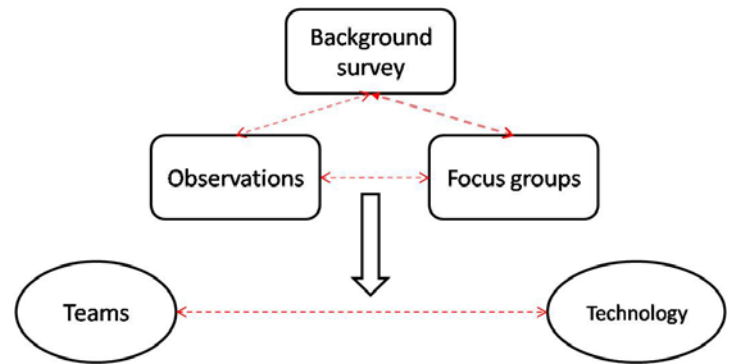


Figure 3. Analysis Framework

As part of the larger study, sixteen teams consisting of 69 participants consented to the study. The quantitative data analysis was primarily centered on the background questionnaire responses. Students' self-rated experiences in design, teamwork, technology, and sustainability were analyzed as a predictor of success regarding the design project assessment using a linear regression model. The full model was only able to explain approximately 4% of the variability in the data,  $R^2 = .04$ ,  $F(4, 64) = 3.63$ ,  $p > .05$ . Consequently, we did not find students' self perceived experience in design, technology, sustainability, and teamwork to be statistically significant predictors based the current methods used in the final design assessment. To examine the specific impact of technology experience on final design evaluation, we reran the linear regression analysis with each of the 4 variables entered separately, and again no results were significant; technology,  $R^2 = .01$ ,  $F(1, 67) = .705$ ,  $p > .05$ .

### Use of technology

I also wanted to examine the design solution sketches and final product for any relationship between prior experience in technology and how each team member communicated their design to other members of the group. The ability to facilitate electronic sketching is one unique feature of the tablet PC that not only allows an individual to externalize their conceptual design, but also allows each individual to synchronously communicate their design to everyone else with the additional support of online collaborative software, e.g. OneNote sharing sessions. Team 2, highest technology experience, utilized the electronic sketching methods over paper-based sketching while the other teams only partially used electronic sketching or no electronic means to create their sketches. The electronic sketches were an important form of external representation in team communication because the digital representations were easily shared synchronously during meetings, e.g. through OneNote sharing sessions, and asynchronously outside of team meetings, e.g. email communication. Conversely, we found that teams with low experience in technology had difficulties communicating design experiences and even had low-level communication problems, e.g. rescheduling of meeting times.

Team 2's self-reported average score for experience with technology was only 3 and had several difficulties in communication, which specifically resulted from problems with their use of technology. During the focus group interview, one member expressed that the breakdown of communication within the team resulted from other members not being as connected with their email as other members and how that influenced the overall group dynamic.

Member 1: Some didn't check their email for days whereas some of us check it almost every hour. So, when it came time to last minute changes for, say a meeting time, we had something come up. They all end up not knowing what's going on, you meet at eight and the meeting is really at nine thirty and they don't show up. We didn't really get much accomplished as a group because two of us would be working on it and then the other wouldn't even contribute.

This team was also unfamiliar with technologies associated with the tablet PC, e.g. OneNote sharing sessions, and therefore did not implement it into their group meetings and team design process.

#### *Adoption of Technology*

Based on the observations of technology use and focus group interviews we found that teams with previous experiences with technology, and more so successful experiences, were more likely to implement and attempt to implement and utilize different features of the tablet PC in comparison to those teams who reported low experiences in technology. For example, Team 4 expressed in the focus group interview that integrating features of the tablet PC and communication practices was not even feasible due to team member experience with technology.

Member 3: (referring to using remote locations for Onenote sharing sessions) No, that didn't work. It was hard to get everyone to commit and then other people would have issues signing into the session so we'd only end up with half of our team meeting or just giving up.

Team 2 on the other hand, integrated features of the tablet PC and collaborative programs to facilitate team communication throughout the design process. This team made extensive use of OneNote sharing sessions communicated asynchronously with each other and the client through email/ google docs and the online wiki. Team 2, Member 1 also recognized the importance of the wiki with respect to efficiently utilizing access to the overwhelming amount of data available.

Member 1: it was just easier to refer to the wiki instead of emailing or googling solutions.

Overall, Team 2's design (wood gasifier) was chosen by the client as an innovative design based on their creative solution to utilize sustainable practices over their current non-sustainable practice. Table 1 summarizes the client rating for Team 2's final design.

Table 1  
*Client Qualitative Feedback*

Project	Feasible	Creative	Meet our Needs	Efficiency	Comments
Wood Gasifier	yes	yes	yes	high	"They provided numbers to help us figure out efficiency. We would like to implement this. Good job."

## CONCLUSIONS AND DISCUSSION

The team that used a combination of face-to-face interaction and technologies during the design process received positive client feedback and produced an innovative design, i.e. implemented over existing design. Team 2, (M=6, technology), used a combination of technologies, e.g. wiki and OneNote sharing sessions during face-to-face team meetings and received very high ratings regarding the final design. Through these interactions, team members were able to visualize their conceptual design ideas through digital external representations. Although previous experience in design, technology, teamwork, or sustainability were not quantitatively significant predictors of overall project assessment, the team that had the highest rated experience in technology utilized different features of the tablet PC and other collaborative software and the client ultimately chosen their design for implementation.

In this study, we explore the role of a pen-based technology and the specific effects of the tablet PCs on team communication and matching design practices. We further investigate how technology and communication shaped subsequent design practices. In addition, we examined teams' utilization and adoption of technology through design artifacts, observations, and focus group interviews.

One critical distinction of this study from others, is the emphasis on understanding the use and adoption of the unique feature of the tablet PC and their implication for future user centered design, rather than the tablet PC as an end all technology. New technologies and developing interfaces associated with the iPad and Windows 7's support for tablets will hopefully expose technologies and implement them into the mainstream. Therefore the goal of this work is to provide

an understanding of how these features and technologies can enhance creativity and human interaction for future designers. As with every study, the study has a few limitations. First, the small sample size may have had an effect on the significance of the results. The next stage of analysis will include a larger sample size. Second, the use of a self-report online questionnaire may have had an impact on the significance of the results as well as cause an “halo effect” (i.e. reports of performance tend to be slightly inflated by respondents) (Pike, 1999). In the future, we suggest supplementing online questionnaires with focus groups/interviews prior to team assignment, to get a more accurate representation of their previous experience.

### ACKNOWLEDGEMENT

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