# AC 2009-1039: EFFECTIVENESS OF SHARED TABLET PC USE ON FACILITATING STUDENT INTERACTIONS

**David Bowman, Clemson University**

David R. Bowman is a Lecturer in the General Engineering Program within the Department of Engineering and Science Education at Clemson University. He is also a Computer Science Ph.D student in the School of Computing at Clemson University. His educational background includes a B.S. and M.S. in Computer Engineering from Clemson University.

**Lisa Benson, Clemson University**

Lisa Benson is an Assistant Professor in the Department of Engineering and Science Education at Clemson University, with a joint appointment in the Department of Bioengineering. Dr. Benson teaches first year engineering, research methods, and graduate engineering education courses. Her research interests include student-centered active learning in undergraduate engineering, assessment of motivation, and how motivation affects student learning. She is also involved in projects that utilize Tablet PCs to enhance student learning. Her education includes a B.S. in Bioengineering from the University of Vermont, and M.S. and Ph.D. degrees in Bioengineering from Clemson University.

# Effectiveness of Shared Tablet PC Use on Facilitating Student Interactions


## Abstract

The objective of this study is to examine how Tablet PCs affect the interaction between students when working in pairs on in-class assignments, and to study the effects of shared Tablet PC use on learning. Prior studies have demonstrated that engaging students in the learning process through active discussion and/or problem-solving with their peers improves learning. Tablet PCs allow students to engage in learning activities while using unique digital Inking and sharing capabilities.

In this pilot study, significant differences were observed between students working on paper and Tablet PCs ("Paper" and "Tablet," respectively) in terms of the frequency of observations that students were working in pairs (36% for Paper vs. 50% for Tablet) and working by themselves (43% for Paper versus 24% for Tablet). The predominant activity for both groups was talking, followed by writing, reading and listening; no significant differences were observed for frequency of these actions. Scores on relevant test questions and in-class assignments were not significantly different between the two groups, nor were significant differences observed between these groups on motivation survey constructs. Students in the Tablet group agreed more strongly with the statements, "Collaborating with a partner on problems helps me understand concepts in this class," and "I paid attention most of the time," compared to students in the Paper group.

Tablet PCs effectively increased interaction between students working in pairs, and appear to promote positive interdependence for the students in this study. More long-term studies are being conducted to assess effects on learning and student attitudes over time, and to improve the inter-observer reliability statistics.


## Introduction

Pen-based technology is a powerful tool in engineering and science education, as it allows students to write freeform symbols, structures and equations. Students can work through problems, take notes, organize class materials, and store these materials electronically without an equation editor or concerns about formatting. Through a 2007 Hewlett Packard Technology for Teaching grant, our program has acquired 36 Tablet PCs for students to use for in-class activities.

Theories of meta-cognition show that when students verbalize their thinking, they are more conscious of their own understanding, and are able to identify inconsistencies in their problem-solving strategies[1]. When working in pairs, students must verbalize to each other the process they are following to work out a problem. Given these benefits, we encourage students to work through problems in class in pairs or small teams of 3-4 students. The purpose of this study was to examine how, if at all, using Tablet PCs in the classroom affected interactions between students working in pairs.

In computer science, researchers often pair students working on programs in introductory computer science courses to discover what gains students demonstrate in contrast to individual programming. Research in pair programming has shown an increase in student retention in computer science, higher success in the pair programming courses, gains in self-confidence, and reduction in the number of problems for which students need assistance[2-4]. The implications of work in pair programming led to the question of whether or not there could be similar gains for students solving fundamental engineering problems in a first year course.

One of the learning objectives in our introductory engineering course is to analyze and manipulate data, or in other words, build models based on a given set of information and criteria. According to Bandura[5], the necessary conditions for effective modeling are attention, retention (recall of what the student paid attention to), reproduction of the material, and motivation. Based on this framework, we developed a methodology to study the factors contributing to a major learning objective in our course: manipulating information and criteria to solve.

**Experimental Design**

Students in our introductory engineering course for first year students were paired up by self-selection, and were assigned a set of practice problems to work through during a 50-minute class period on the topic of energy efficiency. Students were instructed to take turns thinking through problems and writing out solutions. Four sections of the course were included in this study, with approximately 45 – 50 students per section. Two sections were instructed to work problems together on paper, submitting one set of solutions per pair; the other two sections were instructed to use shared Tablet PCs, submitting one solution file per pair. Two sections each were taught by the study co-authors, and each instructor taught one section working on paper and one working on Tablet PCs. This experiment was conducted over a one week period, with the four sections each being observed once during the week. We have examined the actions of students in pairs, and the direction of those actions, through an observation protocol[6]. We have also collected student performance data on a homework assignment given on the topic that students worked on during the classroom observation period. These data were compared for the students writing out the problem solutions on paper and Tablet PCs using Chi square analysis and t-test comparisons.

**Classroom Observations**

After a brief period of instruction on the topic (five minutes), students were given two problems to work through for the remainder of the 50 minute period. They were instructed to do their work in pairs. During this time, instructors observed the interactions of the students with their peers and instructors (two instructors and two teaching assistants). A classroom observation protocol was used to track student interactions and the focus of those interactions.

- Observe and record the behaviors of four randomly selected students, drawing from all areas of the room. Choose a student, and then observe a student next to him or her, avoiding observation of primarily the students who attract attention with unusual or outgoing behavior.
- Record the observed student's behavior and the direction of that behavior.
    - **Observed behavior is best described as:**
        - Talk
        - Listen
        - Read
        - Organize*
        - Write**
        - Other_______________
    - **Observed student's behavior is directed to:**
        - Instructor
        - Group
        - Another Student
        - Self/Notes

  *"Organize" includes organization of materials, transition, or movement
  ** "Write" includes taking notes or board work
- Repeat these steps for four students every 5 minutes.

Reliability checks were performed by having two instructors observe the same student as one of the four observed during each round of observations. Each instructor made six to seven rounds of observations during the class period, making between nine and fourteen reliability checks. A total of 398 observations (192 using paper, 206 using Tablets) were made. Between observations, instructors guided the students and answered their questions as they worked through the problems. The problems that students were assigned in this study pertained to energy efficiency. Assignments were graded using a rubric based on formatting (proper header, neatness, etc), appropriate problem-solving strategies, proper use of equations, variables and units, and correctness. Grades on these assignments were compared for the students working on paper and on Tablet PCs.

A 40-item motivation and attitude survey[7] was administered to the students after the experimental class sessions. This survey measures four aspects of motivation:

1. Value of being an engineering student
2. Value of becoming an engineer
3. Usefulness of course in achieving the goal of becoming an engineer
4. Self-efficacy

The following questions of interest were added to the survey to assess student perceptions of attention, learning and interaction with peers:

1. Most students were actively involved.
2. I contributed meaningfully to discussions in class.
3. Most students were not paying attention.
4. I paid attention most of the time.
5. I participated in the class most of the time.
6. Collaborating with a partner on problems helps me understand concepts in this class.
7. Working alone on exercises helps me understand concepts in this class.

All survey questions had a Likert-scale response ranging from 1 ("Strongly Agree") to 5 ("Strongly Disagree"). Survey scores for both groups of students (paper/pencil and Tablet PC users) were compared using a t-test at the 95% confidence level.

**Results**

Reliability check of the classroom observation protocol revealed that when the same student was observed simultaneously by two instructors, observations agreed with each other for 56% of the replicated observations (n=100). Because observations were made anonymously, it was not possible to exclude results that were not in agreement, so all observations were included in the following analysis.

Chi square tests revealed significant differences in the action-direction of students between the Paper and Tablet groups. The most significant difference was in frequency of students working in pairs (36% for Paper vs. 50% for Tablet) and working by themselves (43% for Paper versus 24% for Tablet). The predominant activity for both groups was talking (Paper, 30%; Tablet, 38%), followed by writing, reading and listening; no significant differences were observed for frequency of these actions. Results are summarized in Figures 1 and 2.

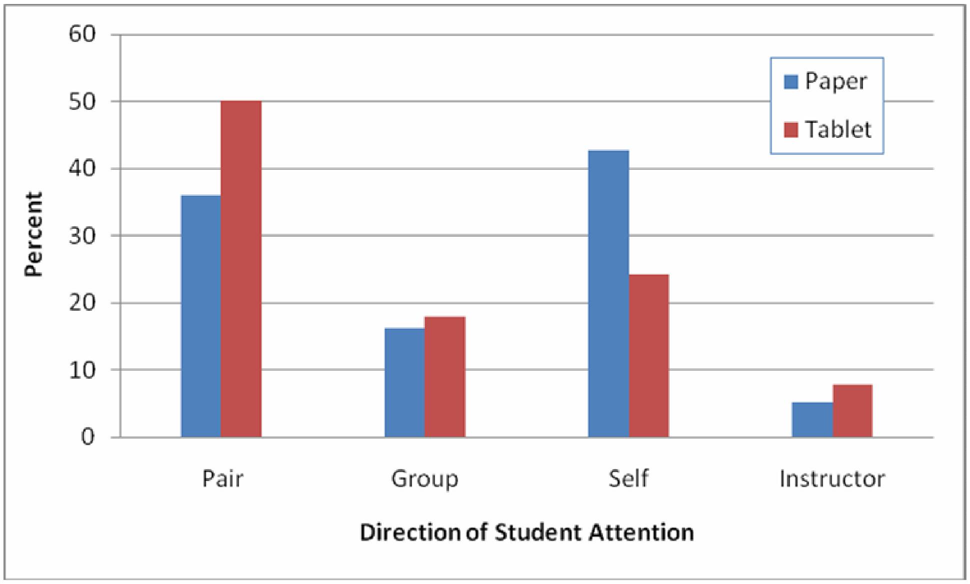


Figure 1. Percentage of observed students directing their attention to one of three individuals or a group of students for those working with either paper or pencil (n=192), or Tablet PCs (n=207).

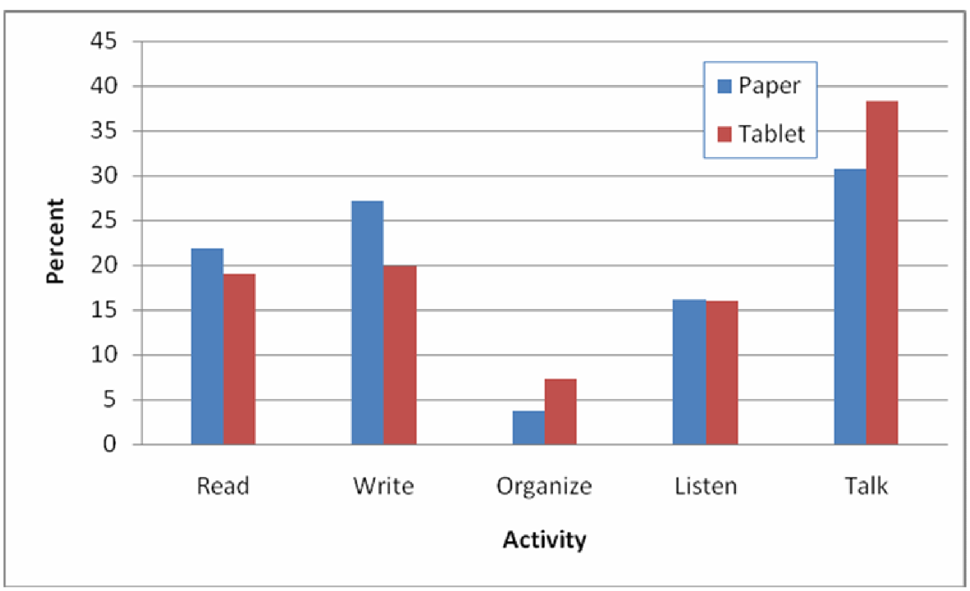


Figure 2. Percentage of observed students engaging in one of five different activities in class while working in pairs using either paper and pencil (n=192), or Tablet PCs (n=207).

Scores on relevant questions on homework assignments were not significantly different between the two groups. No significant differences were observed between these groups on motivation survey constructs, but all constructs contributing to motivation were positive. (On a scale of 1 to 5, where 1 = "Strongly Agree" and 5 = "Strongly Disagree," a score of less than 3 indicates a positive attitude.) Based on t-test results comparing survey question scores, students in the Tablet group agreed more strongly with the statements, "Collaborating with a partner on problems helps me understand concepts in this class," and "I paid attention most of the time," compared to students in the Paper group ($p=0.03$ and $p=0.05$, respectively). Survey responses are summarized in Table 1. Tablet PCs may improve peer interactions because students using them are focused on the computer as a unique tool. Students instructed to work in pairs have only one object to focus on when using a Tablet PC for communicating their work, forcing them to work together with that tool; students working with paper can more easily work individually because of the ubiquitous nature of paper as a communication tool.

Table 1. Mean (standard deviation) scores on attitude survey. A score of less than 3 indicates a positive attitude; the lower the score, the stronger the agreement with the statement. Shaded questions of interest were significantly different for students using paper/pencil vs. Tablet PCs ($p < 0.05$).

| Survey Construct / Question of Interest | Tablet | Paper |
|---|---|---|
| **Value of being an engineering student** | 2.11 (0.38) | 2.21 (0.53) |
| **Value of becoming an engineer** | 1.82 (0.50) | 1.83 (0.61) |
| **Usefulness of course in achieving the goal of becoming an engineer** | 1.49 (0.39) | 1.59 (0.47) |
| **Self-efficacy** | 0.51 (0.41) | 0.62 (0.46) |
| **I paid attention most of the time.** | 1.56 (0.59) | 1.79 (0.77) |
| **Collaborating with a partner on problems helps me understand concepts in this class.** | 1.74 (0.60) | 1.96 (0.84) |

**Conclusions**

This pilot study has demonstrated that Tablet PCs may facilitate peer interaction in class by encouraging students to work through problems in pairs, while allowing them to enter freeform symbols, sketches and equations. The study was limited by the low inter-rater reliability[8], and the single replication of the classroom observation protocol, both of which will be addressed through future replications of the study. Future directions for this research include tracking the strategies used by students to work through problems, both individually and in pairs. This will be done using software designed by our research team to replay the electronic ink, and tagging specific components of problem-solving strategies such as problem statement, identification of variables, appropriate use of equations, and proper unit conversions. These strategies will be examined for students working on paper and on Tablet PCs to further our understanding of the impact of pen-based technologies on learning.

This work was funded in part through a Hewlett Packard 2007 Technology for Teaching Grant.

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