EDUCATIONAL BENEFITS OF A PAPERLESS CLASSROOM UTILIZING TABLET PCS

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Our research assessed specific educational benefits that tablet PCs may have over laptop computers and hand written notes in university classrooms. This resulted in a number of significant and unexpected findings.

The research was based on the incorporation of PowerPoint® presentations converted to Windows Journal® presentations on a tablet PC, wireless technology, and MIT's Stellar system (a web-based course material delivery system). These technologies can be adapted to laptops, but when used with the tablet PC several distinct advantages became apparent. The first major advantage was improved academic performance. The second was increased effectiveness in teaching and learning.

METHODS

Three independent studies were designed to assess the effects the tablet PC can have on educational performance. In the first study, 22 students in a 2003 introductory neuroscience class were given tablet PCs. The remaining 48 students relied on traditional note taking. In the second study, all students in a 2004 advanced neuroscience class used tablet PCs. Their performance was compared to that of 21 students who took the same class, taught by the same professor in a previous year, but who did not use tablet PCs. In this second test the assessment related to the amount of information that could be given without increasing the

amount of time that a student needed to study or decreasing the students' academic performance. The performance factors in both studies were quiz grades, homework assignments, midterm and final examinations and final grades. In the third study, an evaluative summary was made of the performance of seven students who used tablet PCs in an introductory class in Mandarin Chinese. Students could write Chinese characters directly on their tablet PCs and receive immediate feedback. Statistical measurements were made using Pearson's 2-tailed Correlation, Levene's Test for Equality of Variances, and the two-tailed t-test for equality of means.

ACADEMIC PERFORMANCE

<u>Improvements In Student Performance</u>

In the first study, the use of a tablet PC resulted in significant increases in performance on the final examination and final grade, $p < .003$, (Figure 1). Additionally, we found a statistically significant difference on their quiz results, $p < .036$, (Figure 1). There were nonsignificant increases in the mean scores of tablet PC users over non-tablet PC users in their midterm examinations and homework assignments (Figure 1). However the midterm average for those students who used tablet PCs included the scores of 9 (43%) who had received their tablets only a week or two prior to the examination.

Figure 1

□ Non Tablet PC Users ▨ Tablet PC Users

Difference in Mean Performance Scores of Tablet PC Users and Non Tablet PC Users
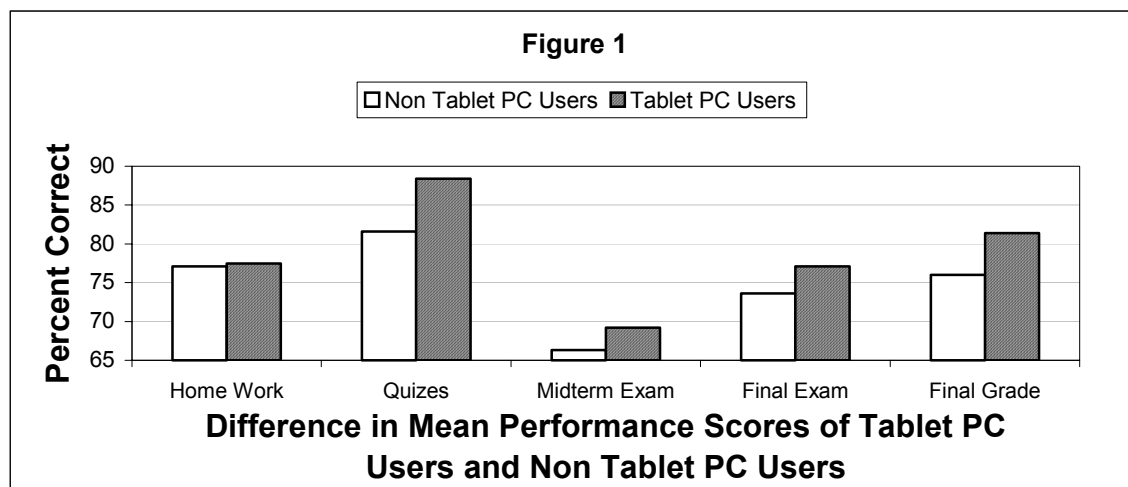
Decreases in the Number of Students Who Perform Poorly

In this same study, a more detailed analysis was undertaken with regard to the distribution of scores across all of the academic measures described above. Students who performed in the bottom 15% of their class on all measures were essentially only those who did not have the use of the tablet PC (Figure 2).

Figure 2

	Non Tablet PC Users	Tablet PC Users

Number of Students Scoring in the Lowest 15% on Performance Measures
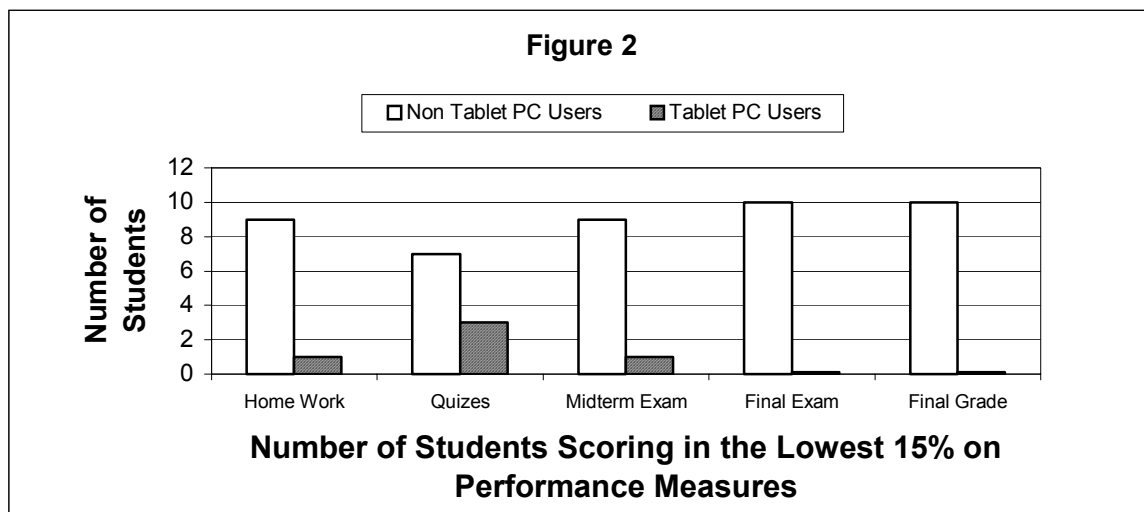
This dramatic result suggests that the tablet PC, together with the other teaching methodologies used, enabled struggling students or students who had different learning styles, to adjust to course requirements because of the versatility of the tablet PC. This is the first time that this type of analysis with regard to tablet PCs has been done, and the results are encouraging and thought provoking.
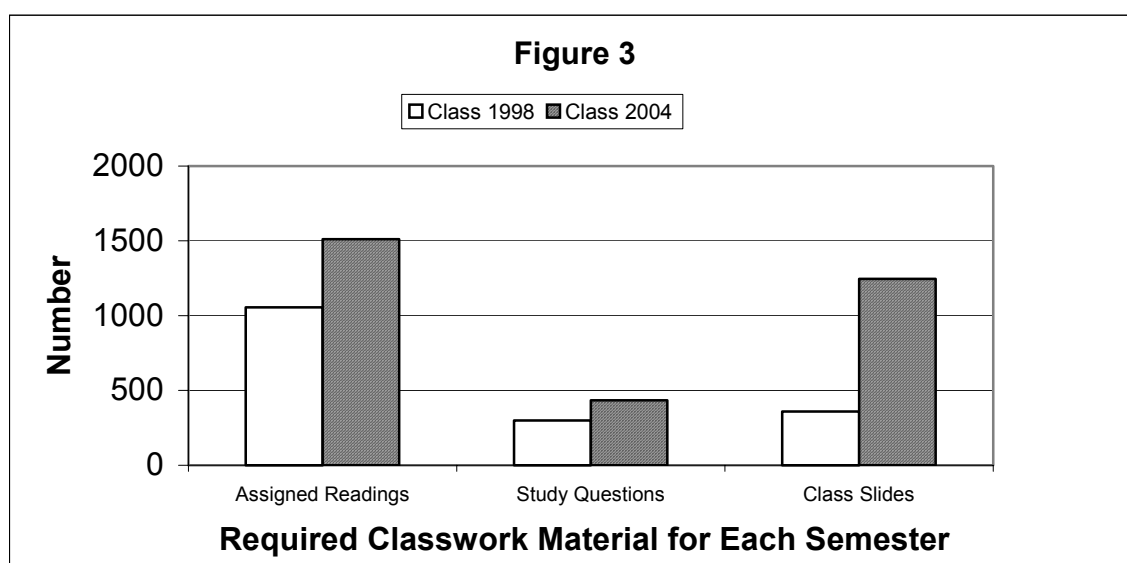
Increases in the Amount of Information Delivered

In our second study we compared two identical classes offered in 1998 and 2004 by Professor Gerald Schneider (*Brain Development and Neuroanatomy*). In 1998 students and faculty had

no use of tablet PCs, PowerPoint® presentations, Windows Journal® or Stellar whereas in 2004 they did.

In 2004 the pages of required reading given to students increased 43% and "study questions" increased 45%. The number of slides presented in the class increased 347% (Figure 3). Student performance, as assessed by final grades, quiz and examination scores, did not decrease even though the amount of material increased significantly. Surveys given to students at the end of the semester indicated that students did not need to spend more time studying, nor did they rate the level of difficulty of the class any greater.

Figure 3

☐ Class 1998 ▨ Class 2004

Number (y-axis: 0, 500, 1000, 1500, 2000)

Categories: Assigned Readings, Study Questions, Class Slides

Required Classwork Material for Each Semester

INCREASED EFFECTIVENESS IN TEACHING AND LEARNING

Ease of Organization and Editing of Class Material and Notes by Students

Students repeatedly described the ability to organize their course materials as one of the greatest advantages to using tablet PCs. The most distinctive aspect was that hand written notes could be organized and integrated with other class material. When implemented with

Stellar or any comparable web-based course delivery system, the tablet PC enabled students to download a professor's class notes, slides, including pictures, graphs, tables, and reference materials. All of this material was coordinated with the student's notes and organized in any manner through such techniques as copy and paste, captioning, auto formatting, keywording, and document merging.

In response to end-of-semester survey questions given to students in our first study, tablet PC users reported that they were able to organize their time more efficiently than non-tablet PC users ($p<.001$), their course materials at an even greater level of significance ($p<.00015$), and their notes at the highest level of significance ($p<.0001$) (Figure 4).

Figure 4

Students' Perception of How Well They Were Able to Organize Their Time, Class Notes and Course Materials
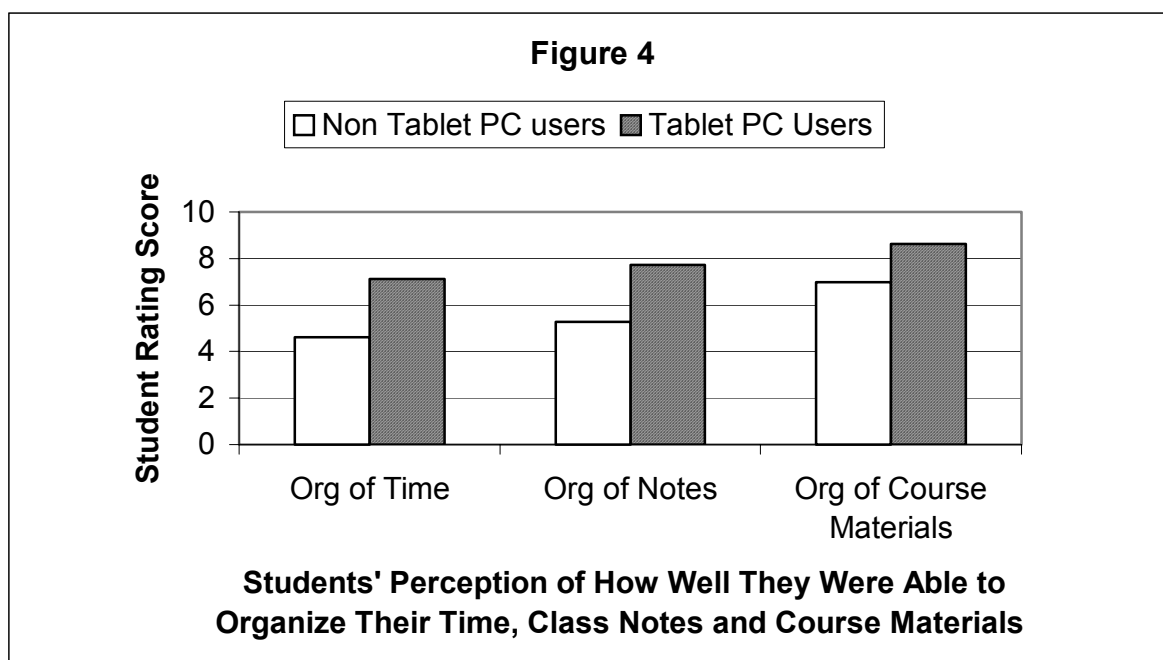
It is meaningful to think of how the tablet PC might help those students who struggle with organizing their course material or are likely to decrease their efforts to maintain a high level of organization because of time constraints or the stress of school. In addition, we can think of

how the tablet PC could benefit students who might have greater difficulty learning due to learning disabilities including ADD.

<u>Provision of Illustrations in Color Digitally through the Wireless Network</u>

A second advantage of the tablet PC was the ability of students to have class materials in color, and take notes in color. Virtually all students who used tablet PCs used colors to make their notes more legible or to encode information pertinent to a given slide. Most students used multiple colors to draw their own diagrams and graphs. Students who used tablet PCs reported that their ability to understand course material improved with handouts downloaded in color. When compared to students who used the standard printed handouts that were not in color, the difference was significant (p <.002).

An overwhelming number of students mentioned the addition of color as being the primary change in note taking style as a result of the tablet PC. Students used color to highlight relevant information and to draw directly on diagrams and slides. What is clear in evaluating the students' notes was that color was used as a valuable note-taking resource.

<u>Ability to Provide Immediate Feedback to Students on Their Performance</u>

Electronic tests and quizzes are an efficient way to assess learning and can provide students with immediate feedback as to their performance. It is well known in learning theory that immediate feedback is a great advantage in increasing learning efficiency. [1]

In a dramatic demonstration of the effectiveness of feedback, we incorporated the tablet PC in one Mandarin Chinese class under Professor Julian Wheatley, which includes learning to write Chinese characters by hand. The students downloaded and completed homework by writing on their tablet PC screens. Students emailed their homework to their professor who corrected them on his tablet PC and sent the corrected version back. Software also enabled students to

test themselves on writing Chinese characters. Students could write characters directly on their monitors, test their progress, and get immediate feedback. On a scale of 1-10 with "1" being "extremely useless" and "10" being "extremely useful," students who took Mandarin Chinese in Spring 2004 were unanimous in scoring the tablet PC a "10." According to the students, the tablet PC enabled them to learn Mandarin Chinese with much greater ease and in less time. In a similar way, the tablet PC could be used and adapted for all course material that requires at least some expression of knowledge in nonlinguistic or spatial formats such as in architecture, engineering, molecular biology, anatomy and mathematics.

Adaptability of Tablet PCs to Individual Learning Styles

Tablet PCs seemed to increase the effectiveness of learning because it was adaptable to the individual learning styles of students.[2,3,4,5] During the second study, daily observations were made of the students' note taking, and students were interviewed and surveyed by an expert in educational assessment, revealing many different learning styles. All students in *Neuroscience and Behavior,* 2003 were provided with a CD to record their class notes, which were examined by the investigators. The stylus was the predominant means of note taking on the tablet PCs. Few students relied primarily on the keyboard. The majority augmented their stylus-based notes with typing. Several students took very few class notes but listened to the recorded course material after class in conjunction with the professor's slides. Other students, rather than taking notes on paper, wrote most of their notes in color on the downloaded class slides.

Most apparent was that **the tablet PC was adaptable to the student's learning strategies, styles, and preferences regardless of what those might have been**. This characteristic of the tablet PC has been largely unrecognized. Although this versatility may also reflect the use

of other forms of technology, the tablet PC gave students distinct advantages, including the ability to integrate hand-written notes and course materials, use color, and increase the ease with which their course material could be organized.

OTHER NOTABLE OBSERVATIONS

Briefly, we discovered three additional factors that had a dramatic effect on students use and performance with the tablet PC. First, the size and weight of the tablet PC met a critical threshold for portability that resulted in students carrying and using them at least ten times as often as a laptop PC. Second, students had a great feeling of comfort and security because all of their class material and notes could be backed up on one CD and were useable whenever there was a desktop, laptop or tablet PC available. Third, students saw the opportunity to use their tablet PCs for recording data, figures and sketches in their field work exactly like a clipboard. This data could then be easily integrated into their class work and readings.

CONCLUSION

Some of the most compelling findings of our research over the last two years indicate that the tablet PC has a highly significant direct benefit on **student academic performance**. This was especially noteworthy for students who might otherwise perform poorly. Related to this has been our finding that the tablet PC, together with PowerPoint® lecture presentations, has enabled more information to be conveyed to students without increasing the amount of time that needs to be spent studying or increasing student stress.

A second major finding was that the tablet PC increased **effectiveness in teaching and learning**. This was primarily due to the ease of organization of class material and notes of

students, the provision of wireless color illustrations, the ability to provide immediate feedback to students, the adaptability of tablet PC's to individual learning styles, and the ability of both students and instructors to edit their material easily.

[1] V. Shute. *Handbook on Research on Educational Communications and Technology.*
Research and Development Division, Educational Testing Service. Princeton, New
 Jersey, 1994.

[2] S. J. Sims, Editor. *The Importance of Learning Styles: Understanding the Implications for Learning, Course Design, and Education.* Greenwood Press, Westport, CT, 1995

[3] R. Dunn, Editor. *Practical Approaches to Using Learning Styles in Higher Education.* Westport, CT: Bergin & Garvey, 2000

[4] R. M. Felder. "Reaching the Second Tier: Learning and Teaching Styles in College Science Education." *J. College Science Teaching* 23(5) (1993): pp. 286-290.

[5] R. Cartnal and D. Diaz. "Learning Styles in Two Classes: On Line Distance Learning and Equivalent On-Campus Learning." *College Teaching* Volume 47, Issue 4 (1999)

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