A TABLET IS REQUIRED: PROMOTING EFFECTIVE STUDENT USE OF TABLETS IN THE CLASSROOM

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Abstract

In the fall of 2007, the J. B. Speed School of Engineering at the University of Louisville joined the ranks of universities requiring the purchase of tablets for all new, entering students. The Department of Engineering Fundamentals teaches engineering mathematics, and its classes were among the first to be one-to-one tablet classes, that is all students in a class have tablets. From the beginning, students responded favorably to faculty use of tablets for lecture presentation and distribution of skeleton notes. However, many students did not automatically embrace tablets or find them to be a particularly useful note-taking tool. This paper discusses the department's attempt to encourage students to embrace using their tablets for classroom note-taking in departmental as well as non-departmental classes. Students in engineering mathematics courses were required to work and submit an in-class problem using their tablet on daily basis for three semesters. A survey was designed to measure how students were actually using their tablets, and individual student responses were tracked along with measures of academic performance and tablet use. Results show that students' attitudes and utilization of tablets have improved, but distraction is still a challenge.

Introduction

Many schools and universities are incorporating tablet computers and associated classroom learning systems (CLS), such as Classroom Presenter and DyKnow™, into classroom instruction [1]. Of particular interest are one-to-one tablet classrooms where each student has their own tablet. Students can use their tablets to take notes during class; if the instructor makes lecture slides available before class, students can use their tablet to mark up the slides and weave in additional notes of their own. With content learning systems such as DyKnow™ or classroom presenter, students and their instructors are able to markup and share a digital white board. New and interesting types of active and collaborative learning are possible in one-to-one tablet classrooms [2]. However, few students have experience using a tablet prior to entering a program with a mandatory tablet requirement. Therefore, educators in one-to-one environments, in addition to the obvious technical and pedagogical hurdles, also need to help students become effective and efficient users of their tablets.

The J. B. Speed School of Engineering at the University of Louisville began requiring freshmen engineering students to purchase a tablet computer in the fall of 2007. Since only entering freshman are required to purchase a tablet, incorporation of tablets into courses has occurred gradually as the overall percentage of students with tablets increases with each entering freshman class. The Department of Engineering Fundamentals teaches engineering mathematics to freshmen and sophomores, and was the first department to have one-to-one tablet classes. Department faculty Hieb and Ralston describe initial, Phase I, efforts by the

department to incorporate the use of tablets in the Engineering Analysis Courses: Engineering Analysis I (ENGR 101), Engineering Analysis II (ENGR 102), Engineering Analysis III (ENGR 201), and Differential Equations for Engineering (ENGR 205) [3].

Initial efforts by the Department of Engineering Fundamentals to use tablets in the classroom focused on adapting the delivery of existing course material. Hieb and Ralston [3] described the approach used to move from overhead projectors and chalkboard based lectures, to one delivered using tablets and DyKnow™. They also discussed initial attempts at assessing the impact of tablets on both faculty and students. In the initial attempt to incorporate tablets into the class, (from here on referred to as Phase I) students were required to purchase a tablet. The classroom learning system (CLS) DyKnow™ was used to share instructor created skeleton notes during class, but no class activity specifically required students to use their tablet and students were free to take notes during class in any way they chose. From the Phase 1 survey results, it was clear that faculty saw clear benefits to using tablets in their lectures, and many students preferred faculty use of tablets and DyKnow™ to traditional chalkboard based lectures [3]. However, not all students used their tablets in class nor did it appear that most students appreciated the many note-taking benefits of the tablets.

This paper describes the next phase (Phase II) of tablet use in the Department of Engineering Fundamentals' Engineering Analysis courses. In this phase, classroom changes were implemented that were intended to change students' attitudes and use of their tablets. For Phase II, which began in the fall of 2008, students were ***required*** to bring their tablet to class each day. This requirement was enforced by having students submit their work on a short problem, completed using digital ink and DyKnow™, during each class lecture meeting. Current and relevant literature on tablet use in classrooms is presented. The next section explains in more detail the changes implemented in Phase II and describes the development of an improved survey on student use of their tablets. We then summarize and discuss the Phase II implementation and survey results, followed by conclusions and directions for continued effort to improve learning in one-to-one tablet classrooms.

Related work

Since the introduction of the Tablet PC edition of Windows XP in 2002, there has been a growing interest in tablets in educational circles. Papers discussing this trend tend to fall into three categories with some overlap: 1) those that discuss a specific tablet tool, with advantages for student and teacher, 2) those that emphasize the enhanced note-taking and note organization capabilities provided by tablets, and 3) those that describe approaches for using tablets to engage students through active and collaborative learning. Measuring the impact of tablets on performance can be difficult. As Stickel [4] pointed out, it may be that tablet based instruction has the greatest impact on students in the bottom half of the class. By helping students work more efficiently and be more organized**,** it should have some positive impact on their grades even if it is to require less time to achieve the same grade. Student surveys are primarily used to evaluate the efficacy of tablets in the classroom.

Classroom learning systems, or CLS [5], are by far the most common tablet classroom tools. The most commonly used and well known tools include DyKnow™[6], Classroom Presenter[7], Ubiquitous Presenter[8] and InkSurvey [9]. DyKnow™ and Classroom Presenter both provide a shared white space to be used by instructors and students. In addition, both DyKnow™ and Classroom Presenter allow students to submit work on their tablet during class, and the instructor to poll students in real time. Ubiquitous Presenter enhances Classroom Presenter and expands it to support non-tablet

audiences. InkSurvey is a simple and robust web-based tool to facilitate the use of open-ended questions in tablet classrooms. Group Scribbles[10] is a platform that supports more generalized coordination among students and can be downloaded for free from http://groupscribbles.sri.com. There are a number of papers, [7; 11-14], touting the merits of a particular tool; these papers generally focus on those aspects of the tool that encourage active and collaborative learning tablet based note-taking. One case study, presented by Walker et al. [15], specifically addresses the presentation capability of tablets, with survey results from two mechanical engineering classes showing that 90 students are more likely to pay attention during the lecture and recognize salient points when tablets are used. In contrast, Birmingham and DiStasi[5] have interesting survey results that show 154 students seem to prefer CLS and tablets to overheads and chalk boards but not to PowerPoint and OneNote, nor do they find any advantage to tablets, despite the faculty thinking they were providing many more active learning opportunities. Since this survey was administered on-line and was completely optional the results may not accurately represent student's general attitudes.

Many tablet papers, with sample sizes ranging from 26 to 540, and averaging 249 emphasize note-taking; specifically the ability of software and digital ink to improve note-taking and organization [4,16-21]. In Kobayashi's research [22], a meta-analysis of 33 studies related to note-taking in general and not specifically note-taking on tablets, concluded that note-taking and reviewing have a substantially positive effect on student learning and that the benefits can be increased by intervention in note-taking or in reviewing procedures. Specifically, larger intervention effects were found when a framework or instructor notes were provided to students as a guideline for their note-taking. There are many ways this is easily and efficiently done in a one-to-one tablet classroom: DyKnow™, Classroom Presenter, PowerPoint, and OneNote. One paper by Lim et al. [23] has data that shows 86 students placed more value on class attendance and note-taking if partial notes are available for download rather than the entire lecture with annotations. When students could get complete notes without attending class, they often did not attend. Williams et al. [24] discuss how providing notes for students to annotate with their tablets opens up time for more engagement and collaboration.

Other papers, with sample sizes ranging from 15-55 and averaging 45, report that faculty and students like the active learning and collaboration that can be accomplished in some classes and the immediate assessment that is often possible via polling or collection of student work [19,20,25-30]. Many of these papers relied on surveys or a combination of surveys and classroom performance. Those that were based on performance had very small sample sizes, although larger studies are planned [30]. They report that formative feedback appeared to be the most significant improvement that affected learning. Methods employed for student/teacher and student/student collaboration to achieve improved interaction and engagement include: using polling and in-class testing and feedback [31, 32], interactive learning networks [33] improving teamwork via digital collaboration [34], and developing an advanced learning laboratory and a digital ink based computerized testing system [35].

Enriquez's interactive learning network [33] showed immediate feedback resulted in statistically significant improvement in quiz and homework scores from two case studies of 57 students. The comparisons of classes taught using tablets and DyKnow™ software with traditional lecture classes from Bravo and Batson [31] showed no statistically significant difference in the understanding of the subject, thermodynamics; however, the 28 students that used tablets reported greater satisfaction with the course than the 34 students in the control group. Garcia and Cruz [34] report achieving 100% retention of 20 students with the addition of tablets in several computer science courses at a minority institution. Hrepic and Reed [36]

analyze the learning gains in an inquiry-based physical science course for elementary education majors. They compare the learning gains of 103 students in three semesters when pen-based technology was not used with gains of 80 students during three subsequent semesters with the utilization of tablets and DyKnow™ software. The study did not show cumulative beneficial effect of the technology on gains in student learning; but, it did show positive, but not significant, differences. O'Brien and Dean [37] report quantitative data showing student improvement in mathematics from a trial tablet deployment for 15 students. These students used tablets and 49 students in traditional classes did not. Results support the use of tablets as an effective instructional tool with demonstrated performance increases for students.

Samson [38] discusses laptops for use in keeping 182 students engaged in large lecture classes . Specifically, he presents LectureTools, an interactive suite of tools designed specifically for larger classes. The issues he discusses are relevant for tablets as well as laptops. He provides a convincing argument that laptop use can provide pedagogical benefits that outweigh the potential distractions. LectureTools provides mechanisms to support active learning via engagement; including the ability to take notes synchronized with the instructor's slide, pose questions and get answers in real-time during lecture, reflect on and report understanding during lecture, and the ability to respond to questions asked by the instructor and see results in real-time.

Several of the papers included in this review acknowledge that students are often distracted by non-class related software applications and therefore fail to stay focused on the material. Williams et al. [21] state that this drawback can be mitigated once students realize the benefits of instructor provided notes. Kraushaar, Chittenden, and Novak [39] actually gathered data on use of distracting software such as gaming or email and discuss briefly the difference between laptop and tablet distractions. A disturbing finding from this analysis of 108 students was that on average, students using a tablet during class opened 93 active windows during a 75 minute lecture. The CLS DyKnow™ includes a feature that allows the instructor to block specific programs on student's tablets to discourage distractive tablet use.

Affecting Students' Use and Attitudes Toward Their Tablet

Soon after the J. B. Speed School of Engineering began requiring freshmen to purchase tablets, the Department of Engineering Fundamentals began teaching its core engineering analysis courses using tablets and the content learning system DyKnow™. Hieb and Ralston [3] describe in detail how the department re-worked courses to make tablets part of the course. Tablets are now used by faculty, along with DyKnow™, to present and share lecture material, but in Phase I students were free to adopt any note taking method and no advice or guidance was given to students about specific strategies. Student surveys, administered by faculty, indicated general student support for instructor's use of tablets, but also highlighted some deficiencies. In response to these results, an additional component was added to the classes and an improved survey was developed. Course changes were implemented beginning in fall 2008, and surveys were administered, in the summer and fall of 2009, to a second cohort of students, referred to as Phase II.

Problems Identified in Phase I Implementation

At the end of Phase I, when students were required to purchase tablets but not continually use their tablet in class, survey results showed definitively that students in engineering analysis courses preferred the material be delivered with the CLS DyKnow™ and that instructors continue to use tablets [3]. However, it was apparent that many students were not using their

tablets in other courses, and that most students failed to appreciate the many note-taking benefits of the tablets. As noted by Hieb and Ralston, students used a variety of note-taking techniques, with some choosing to continue using pencil and paper. Few students reported that they preferred their tablets for any type of note-taking or studying. Furthermore students reported little tablet use in classes where the instructor did not use a tablet. Department of Engineering Fundamentals faculty agreed that students' note-taking and note organization abilities would benefit from improved tablet utilization. Furthermore, faculty felt strongly that it was possible to positively impact students' attitudes about their tablets, specifically to help students embrace tablets as a useful educational tool. Faculty agreed that a classroom modification could be an appropriate approach for impacting students' attitudes about their tablets. However this modification needed to fit with the existing course delivery without requiring substantial course re-design. Faculty agreed that students must be required to use their tablet in a specific and targeted way, and that any intended impact needed to be measurable by survey. Students in courses with the developed modification make up Phase II.

Phase II: In-Class Problem Requirement

In engineering analysis classes taught by the Department of Engineering Fundamentals, an effective way to engage students has been to have students work problems in class, and give them some credit on weekly exams for completing these problems. This practice encourages students to attend class regularly and keeps them actively engaged in the material. In-class problems had always been done on paper, even after the switch to tablets. The choice to continue paper in-class problems was a practical one: electronic collection during class required using DyKnow™'s retrieve panel feature. For those unfamiliar with DyKnow™® a brief overview is provided in Appendix A. For large multi-section classes duplicating the paper process electronically would require significantly more time than the paper process. It was clear that moving from paper to e-ink in-class problems offered an excellent opportunity to have the impact desired by faculty, since students would be required to use their tablets each day during class, and the change would fit easily into the existing course structure. However, to implement this change a technical solution to the management of large, multi-section, collections of e-ink in-class work was needed.

The open source DyKnow™ Panel eXtractor (DPX) [40] custom software was developed through a partnership with Engineering Fundamentals Faculty and a Computer Engineering student. The DPX tool was developed to assist instructors in managing in-class problems collected through DyKnow™® and is discussed in detail in [41]. The DPX tool is currently being used by faculty to support scoring of in-class problems retrieved through DyKnow™ in significantly less time than when paper was used. Figure 1 shows a sample report generated by DPX listing the student by section and name and the number of completed in-class problems for a given period of the semester.

Redesigned Survey

The survey used to evaluate Phase I of tablet use [3] shown in Appendix B, was modified for Phase II and is shown in Appendix C. The Phase I survey was re-designed with a narrower focus so that it would be possible to clearly capture how students are using their tablets and to elicit specific responses as to whether or not the tablets and associated software were actually benefiting students. Also, questions were added to the Phase II survey to see if students were using their tablets improperly during class, (i.e. for email, chat, or browsing the web) and also to see what students would self-report in an open-ended question about tablet use. This change prevents formal statistical comparisons from Phase I to Phase II since the questions are not identical, but attitudes and use still emerge and some descriptive statistics can be compared.

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Section 1
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Doe, John              2
Smith, Jane            1
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Section 2
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Doe, Jane              2
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Figure 1. DPX in-class report.

Results

This section presents the results from Phase II. Phase I began in the spring of 2007, when the department of Engineering Fundamentals first began using tablets in class. During Phase I, DyKnow™ was used by instructors to present prepared skeleton notes to students, but students were not required to take notes with their tablets. In Phase II DyKnow™ was still used for distributing daily skeleton notes but students were additionally required to use their tablets and DyKnow™ to complete daily in-class problems and students were prompted with tablet based note-taking strategies at the beginning of a course. Phase II began with ENGR 101 in the fall of 2008 and concluded with ENGR 205 in the fall of 2009. Most entering freshman take Engineering Analysis I (ENGR 101) in the fall of their first year, followed by ENGR 102 in the spring, ENGR 201 in the summer, and ENGR 205 in the fall of their sophomore year. A smaller number who are not ready for Engineering Analysis I take a preparatory course in the fall of their first year then take ENGR 101 in the spring, ENGR 102 in the summer, and ENGR 201 in the fall of their sophomore year. IRB approval was obtained to administer the new survey to Phase II students. Students in Phase II took ENGR courses in each semester. In each course, students were required to work problems in-class on their tablets, and completion of these problems counted as part of a weekly exam score. The revised survey was administered to students in ENGR 201 and ENGR 102 in the summer of 2009. 176 of these students agreed to participate in this study (65% consent rate), and the results reported here are only those responses. The survey was also administered to students in ENGR 205 in the fall of 2009. Only 72 students in ENGR 205 in the fall of 2009 completed the survey (46% consent rate). The low response rate is likely related to the fact these are the same students who completed the survey in EGNR 201 in the summer of 2009. The survey was re-administered to these students to provide alignment with when Phase I surveys were administered.

Faculty observed, and survey results confirmed, the e-ink in-class problem requirement resulted in more students using their tablets for note-taking. In Phase I, before students were required to do the in-class problem in the CLS, students would download the instructor provided skeleton notes to their tablet, but almost half reported that they still took class notes with pencil and paper and preferred a paper class pack to using DyKnow™ for class notes (Table 1).

Significant Phase II survey results are summarized in Table 2 and Table 3. Results for the summer classes showed greater than 93% of students used their tablets for taking notes in Engineering Analysis classes, and over 50% used their tablets very often or daily to take notes in other classes. Students' general attitude towards their tablets appears to be positively influenced as well with over 71% of students either "satisfied" or "very satisfied" with their tablet. The requirement of Phase II students to use their tablets daily during class, appears to have had a positive impact on students' use and perception of tablets. Nearly 50% of Phase I students reported preferring pencil and paper for note taking in their engineering analysis classes. Over 90% of students in Phase II reported using either DyKnow™ or OneNote. The difference

Table 1 Phase I-ENGR 205 Fall 2008 Survey Responses.

Statement	Student Response (percent)	
	Agree or Strongly Agree	Disagree or Strongly Disagree
Prefer the use of Tablet PCs **and DyKnow™** for class presentation. (combined questions 10,14)	46.1%	28.5%
The use of DyKnow™ was beneficial to my learning. (combined questions 3,10,14)	54.7%	23.4%
Taking notes on my tablet was beneficial to my learning (combined questions 9,11,12)	41.8%	38.5%
Preference for pencil and paper notes and course notes. (combined questions 5, 13)	47.4%	28.9%
Data collected from 114 students.		

in wording of questions makes a direct comparison impossible, but the fact that over 50% of Phase II students use their tablet to take notes in other classes is a strong indicator that they have a much more positive attitude about using tablets. Another supporting statistic, seen in Tables 2 and 3, a large majority of students (64%-96.5%) in all Phase II classes, rated use of their tablet and OneNote as having a high impact on their ability to stay organized, review material, and study efficiently. It is interesting that students did not report a similar impact on their overall understanding of course material. These results are comparable with the Phase I results, where only 41.8% of students thought their tablets were beneficial to their learning. Questions about distraction were added to the Phase II survey. Approximately one third of Phase II students reported using their tablet for non-class related activities often or daily, and approximately one half reported being tempted to do so. This supports Kraushaar, Chittenden, and Novak's [39] findings about a high incidence of distraction during class among tablet users. The issue of distraction is further highlighted in responses to the open-ended question "*Is there anything else you would like to share regarding your experience using a tablet in your ENGR analysis class*?" For the ENGR 102 class, 30 students added comments, and of that 30, five specifically mentioned distraction was a concern. One student specifically mentioned that within his visual range half of those students observed were off task and this student found that distracting. This could indicate that in tablet classes distracted students may be more likely to distract other students when they are surfing the web, watching videos, or looking at facebook. For the ENGR 201 class, 74 students added comments, and of that 74, seven specifically mentioned distraction was a problem. Interestingly, two other students mentioned that being able to navigate away to something not "too distracting" for a minute or so would actually help them re-focus. They commented it required discipline on their part. These comments were made by students approximately evenly distributed across the performance spectrum, from A-F grades. Similarly, four of 43 comments concerning distraction were made by students in the ENGR 205 fall 2009 class.

Other negative comments from all three classes were mostly related to technical glitches that inherently accompany the initial adoption of technology in the classroom. Positive comments were made concerning the ability to take better notes with tablets, have them organized in one place, and to use tablets in other classes. Some comments also showed frustration that few faculty outside the Engineering Fundamentals Department were using the tablets.

Table 2 Phase II-ENGR 102 and 201 Summer 2009 Survey Responses (Revised Survey).

Statement or Question	Student Response (percent)				
How do you take notes in your Engineering Analysis classes?	**OneNote or DyKnow™**			**Paper/pencil**	
ENGR 201	***93.1%***			***4.3%***	
ENGR 102	***96.7%***			***3.3%***	
How often do you use your tablet take notes in classes other than Engineering Analysis?	**Daily or Often**			**Rarely or Never**	
ENGR 201	***52.2%***			***27.8%***	
ENGR 102	***53.3%***			***21.7%***	
Rate your overall satisfaction with your tablet. (116)	**Very Dissatisfied**	**Dissatisfied**	**Neutral**	**Satisfied**	**Very Satisfied**
ENGR 201	***.9%***	***17.2%***	***14.7%***	***48.2%***	***19%***
ENGR 102	***5%***	***6.7%***	***5.0%***	***58.3%***	***25%***
Please rate the impact of your use of OneNote on your course experience as compared to previous mathematics courses on:		**Enhanced Significantly or Enhanced Somewhat**		**Reduced Significantly or Reduced Somewhat**	
your ability to stay organized	***ENGR 201***	***94.2%***		***1.0%***	
	ENGR 102	***96.5%***		***0%***	
your ability to review material	***ENGR 201***	***79.6%***		***6.8%***	
	ENGR 102	***80.7%***		***3.5%***	
your efficiency of studying	***ENGR 201***	***75.7%***		***5.8%***	
	ENGR 102	***77.2%***		***3.5%***	
your overall understanding of material	***ENGR 201***	***65.7%***		***3.9%***	
	ENGR 102	***64.3%***		***5.4%***	
Please rate the impact of your use of your tablet on your course experience as compared to previous mathematics courses on:		**Enhanced Significantly or Enhanced Somewhat**		**Reduced Significantly or Reduced Somewhat**	
your ability to stay organized	***ENGR 201***	***92.2%***		***1.8%***	
	ENGR 102	***93.3%***		***3.35%***	
your ability to review material	***ENGR 201***	***79.2%***		***6.9%***	
	ENGR 102	***83.3%***		***8.4%***	
your efficiency of studying	***ENGR 201***	***64%***		***10.5%***	
	ENGR 102	***70%***		***8.3%***	
your overall understanding of material	***ENGR 201***	***55.3%***		***5.3%***	
	ENGR 102	***59.3%***		***6.8%***	
How often do you use other applications such as email, chat, or a web browser during class?		**Rarely or Never**		**Often or Daily**	
ENGR 201		***40.9%***		***31.3%***	
ENGR 102		***36.7%***		***25%***	
How often are you tempted to use other applications such as email, chat, or a web browser during class?					
ENGR 201		***28.9%***		***51.8%***	
ENGR 102		***23.4%***		***48.3%***	
Data collected from 116 students in ENGR 201 and 60 students in ENGR 102					

Table 3 Phase II-ENGR 205 Fall 2009 Survey Responses (Revised Survey).

Statement or Question	Student Response (percent)				
	OneNote or DyKnow™			**Paper/pencil**	
How do you take notes in your Engineering Analysis classes?	**95.8%**			**1.4%**	
	Daily or Often			**Rarely or Never**	
How often do you use your tablet take notes in classes other than Engineering Analysis?	**72.9%**			**6.8%**	
Rate your overall satisfaction with your tablet. (116)	**Very Dissatisfied**	**Dissatisfied**	**Neutral**	**Satisfied**	**Very Satisfied**
	5.6%	**15.5%**	**38.1%**	**19.7%**	**21.1%**
Please rate the impact of your use of OneNote on your course experience as compared to previous mathematics courses on:	**Enhanced Significantly or Enhanced Somewhat**			**Reduced Significantly or Reduced Somewhat**	
your ability to stay organized	**93.9%**			**1.5%**	
your ability to review material	**84.9%**			**4.5%**	
your efficiency of studying	**76.9%**			**7.7%**	
your overall understanding of material	**57.1%**			**0%**	
Please rate the impact of your use of your tablet on your course experience as compared to previous mathematics courses on:	**Enhanced Significantly or Enhanced Somewhat**			**Reduced Significantly or Reduced Somewhat**	
your ability to stay organized	**90.2%**			**2.8%**	
your ability to review material	**85.9%**			**7.05%**	
your efficiency of studying	**70%**			**11.4%**	
your overall understanding of material	**52.9%**			**1.4%**	
	Rarely or Never			**Often or Daily**	
How often do you use other applications such as email, chat, or a web browser during class?	**43.7%**			**33.8%**	
How often are you tempted to use other applications such as email, chat, or a web browser during class?	**21.1%**			**40.8%**	
Data collected from 72 students in ENGR 205					

Conclusions and Future Directions

When the Department of Engineering Fundamentals first began to use tablets in their engineering mathematics courses students generally liked and preferred the faculty use of tablets for lecture presentation and distribution of skeleton notes using DyKnow™. However, a large percentage of students did not report using their tablets for taking class notes in their engineering analysis classes or other classes. Based on both classroom observation and survey responses, a marked improvement in student use of tablets was achieved by requiring students to work problems on their tablets and submit them electronically for credit on weekly exams. Other factors, specifically inferior hardware, may have also influenced tablet use for the earlier cohort of students (Phase I), but it is clear that required daily and continued use over three semesters had a lasting effect on students' use of their tablets for taking notes during class. Though college students today are generally experienced users of technology, using tablets as part of their learning practice may not be intuitive. For many students, simply explaining to them the opportunity and possible efficiencies afforded by taking notes with their tablets is not sufficient to lead to lasting and useful tablet adoption. Besides encouraging tablet use by explaining how to use tablets during class, students need repeated prompting to use their tablet during class. Students appear to resist adopting the tablet for class note-taking

if given the opportunity. But when encouraged strongly and repeatedly, the resistance appears to fade for significant numbers of students, and many begin to view their tablets as just another piece of educational equipment. A few high schools and elementary schools are beginning to develop one-to-one tablet programs; as this number grows it may eventually be the case that post-secondary tablet programs will not have as great a need to incorporate tablet training and encouragement for students. But for now it appears that is an important component in a successful tablet program.

Having succeeded in getting more students to accept and use their tablets effectively for note-taking, there are two directions for future work being considered by the department. The first direction is to explore utilizing the unique aspects of tablets to make the classrooms more active. One approach is to have students submit questions they have about homework problems by submitting their work and the question in digital ink. Another approach is the development of tightly integrated, simple, and pen friendly, model or simulation activities with specific learning objectives [42]. The second direction takes its prompt from the strong response by students that distraction presents a serious challenge for them. Investigation of this tablet challenge area must begin with the design of a study to measure how much of a problem distraction is and if and how it can be properly addressed. There are two possibilities: one is teaching students how to manage their own distraction, and the other is to manage it for them. Tools do exist to control improper tablet use, but they are powerful and may possibly violate students' right to privacy. Therefore the first approach may be preferable.

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Appendix A
Basic Overview of DyKnow™

The central elements of DyKnow™ are the panel and the notebook. A notebook is made up of panels much the way a Power Point presentation is made up of slides. DyKnow™ supports digital inking of each panel. Other elements can be added to a panel as well, such as images or text, and digital inking lays on top of any added elements. During a session students and instructors share a common notebook. The instructor's inking of a panel shows up on each student's notebook, unless the instructor uses "private" ink, in which case the instructor's ink is only applied to the instructor's copy of the shared notebook (but can be projected to the class). During a session student's can apply digital ink to their copy of the shared notebook, and this inking is only applied locally. At the end of a session, each student can save a copy of the notebook, a copy which contains any initial material that the instructor included as part of the notebook preparation, the instructor's none private inking during the session and any inking the student applied during the session. The student is free when not in a session to make any additional changes to the notebook. Associated with each panel there is a side note where digital ink can also be applied. For a more thorough discussion of DyKnow™ see the website: http://DyKnow.com.

Appendix B
Original Tablet Survey

Q1: The tablet PC I use for this class is the first computer I have owned
(circle YES or NO)

Besides this course, how many of your courses have used DyKnow™ and or Tablet PCs to present daily lecture material?
(circle one: None,one, two, more than two)

*For the following statements, check whether you **strongly agree, agree, neither agree nor disagree, disagree, or strongly disagree** with the following statements. Please read all the statements first.*

Q2: The use of DyKnow™ and tablet PCs for the presentation and delivery of the course material is preferable to the use of overhead projectors and chalkboards

Q3: I am comfortable and familiar with my tablet, including note taking tools such as OneNote, Journal and DyKnow™.

Q4: I prefer to take notes using pencil and paper, but like using DyKnow™ to receive the instructors' lecture notes.

Q5: I prefer taking notes using my tablet, but I would rather use a tool other than DyKnow™.

Q6: I prefer taking notes using my tablet and the DyKnow™ software.

Q7: If I were **more** comfortable and familiar with my tablet, including note taking tools such as OneNote, Journal, and DyKnow™, I would be more inclined to use my tablet in this and other courses
.
Q8: I take notes on the tablet in my classes, regardless of how the lecture material is presented.

Q9: The use of DyKnow™ to deliver course material enhanced my performance in this class.

Q10: Taking notes on my tablet enhanced my ability to search and review material, thus helping me to study more efficiently.

Q12: Taking notes on my tablet helps me to stay more organized than using pencil and paper and a class pack.

Q13: I would rather receive a class pack than use DyKnow™.

Q14 I would like other classes to use DyKnow™.

Appendix C
Revised Survey

1. How often during this semester in this class have you experienced technical problems?
   a) more than 10 times
   b) between 5 and 10 times
   c) between 2 and 5 times
   d) Less than 2
   e) None

If a-d then answer the following 2 questions
These problems were mostly related to
   a) Windows operating System
   b) The university's wireless network
   c) DyKnow™
   d) Other (Open response)

These technical problems affected my learning
   a) Significantly
   b) Somewhat
   c) A little
   d) Not at all

2. Do you study and review the material provided by your instructor through DyKnow™?
   Never, Rarely, Sometimes, Very Often, Almost Daily

3. How do you take notes in your ENGR Analysis Class
   a. in OneNote b. in DyKnow c. with pencil and paper d. don't take notes
BRANCH on 3

if answer a then:
3a. Please rate the impact of your use of OneNote on your course experience (as compared to previous mathematics courses) by indicating: ***Reduced Significantly, Reduced somewhat, Neutral, Enhanced somewhat, Enhanced Significantly***
   i. your ability to stay organized
   ii. your ability to review material
   iii. efficiency of studying
   iv. overall understanding of course material
   v. motivation to study
   vi. The ability to tag your notes
   vii. Using OneNote's search capabilities

if answer b in 3:
3b. Please rate the impact of your use of DyKnow™ on your course experience (as compared to previous mathematics courses)
Reduced Significantly, Reduced somewhat, Neutral, Enhanced somewhat, Enhanced Significantly
   i. your ability to stay organized
   ii. your ability to review material
   iii. efficiency of studying
   iv. overall understanding of course material
   v. motivation to study

if answered c or d in 3,
3c: please state why.

CONTINUE FROM BRANCH

4. How often do you use your notes to study/prepare for class?
Never, Rarely, Sometimes, Very Often, Almost Daily

5. I use my tablet to take notes in classes other than ENGR analysis classes
Never, Rarely, Sometimes, Very Often, Almost Daily

6. Please rate the impact of your use of your tablet on your course experience (as compared to previous mathematics courses) by indicating: ***Reduced Significantly, Reduced somewhat, Neutral, Enhanced somewhat, Enhanced Significantly***

i. your ability to stay organized
ii. your ability to review material
iii. efficiency of studying
iv. overall understanding of course material
vi. motivation to study

7. Rate your overall satisfaction with your tablet.
Very Dissatisfied, Dissatisfied, Neutral, Satisfied, Very Satisfied

8. During class I use other application such as email, chat, or a web browser:
Never, rarely sometimes, very often, all the time

9. During class I am tempted to use other applications such as email, chat web browser.
Never, rarely sometimes, very often, all the time

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