Abstract
The purpose of this project was to introduce an upper level engineering course to iPad use for classroom instruction. The iPads granted the students access to course materials, discussion boards, blackboard journals, and many other features of electronic teaching devices. The students were required to keep an online journal, with at least one posting per week including a picture, as to the progress of an environmental project. With an iPad the students were able to take the picture, upload it, and create a journal entry all at once which added a convenience factor to the project. The surveys and discussions showed that students enjoyed having an iPad and it did help with the project. However, the students did not use the iPads for note-taking purposes so it did not reduce the amount of paper in the class by a substantial factor.

Introduction
The use of handheld electronic devices as college educational tools is an area of interest to the research and teaching communities (Reid and Ostashewski, 2011; Morsch and Lewis, 2015). iPads were launched in April, 2010 and rapidly sold in stores. Several universities and colleges quickly adopted iPads to enhance student learning (Diemer et al, 2012; Rossing et al, 2012; Nguyen et al, 2015). Current research is in the early stages of studying iPad adoption in classrooms, but there is a clear lack of research-based literature on the applications of such devices in the college engineering classroom (Reid and Ostashewski, 2011; Diemer et al, 2012; Nguyen et al, 2015). In addition, what research is available is focused on pilot studies to see how iPads could be used in higher education. The research does not show a structured, pedagogical approach to adopting iPads or other tablets into the classroom environment (Nguyen et al, 2015).

Instructors may not use technology in their classrooms due to a lack of support or experience with technology (Nicodemus et al, 2014). As the success of educational technology is dependent on its implementation into the classroom environment (Reid and Ostashewski, 2011; Ravishankar et al, 2014), instructors need to be well versed in the technology and have a thought-out implementation plan. Mang and Wardley (2012) recommend that instructors carefully evaluate how tablets will be used in the course and how they will be distributed to the students. The authors also recommend having a thorough knowledge of the tablet operating system and working with the information technology department at the institution.

In 2010 Neilson conducted a survey on 400 iPad users and found that users are predominantly younger. The survey showed that 65% of users were male and 63% were under the age of 35. These demographics are in-line with the general college population (Nguyen et al, 2015). A 2012 Pearson Foundation survey found that 25% of students at higher education institutes own a tablet device (Romney, 2013).

Student surveys are commonly used to gather student perceptions of learning and enhancement of new, innovative educational technology and are a method to measure the success of the new
technology (Diemer et al, 2012). For example, a study was conducted on student perception of learning with iPads in humanities courses, such as English, Journalism, and Music (Rossing et al, 2012). In this study all of the students had access to the iPads in 1 to 7 class sessions during the semester, but were not provided with iPads for the entire semester (i.e. during and out of class). The study found that iPads were an overall success in these classes. Interestingly, the students ranked perceived learning questions higher than perceived engagement questions. The perceived learning questions were about 4.1 out of 5 points, but the engagement questions were ranked about 3.6 out of 5 points. The study cautions that instructional support is important when implementing technology into classrooms. However, the aforementioned study monitored student perceptions and not an increase in student learning (Rossing et al, 2012).

Amick and Cross (2014) taught a mainly paper-less organic chemistry course (exams were still paper-based) with 12 students. All students received iPads with the Notability app for notetaking and a stylus. The study reported that these students had similar to slightly higher grades in the course compared to the 60 students in parallel sections without iPads. Nine of the twelve students commented favorably on the use of iPads in the lecture and laboratory.

A major feature of such wireless technologies is the availability of course materials anytime, anywhere for students and faculty (Rossing et al, 2012). A drawback to such technology is that wireless access to the internet is needed and this is not always available (Goyings, 2013). The main educational uses of mobile technologies are access to information and as a communication and presentation tool. Though iPads have been useful in engaging students, there is no clear literature on how iPads enhance learning outcomes (Li et al, 2013; Nguyen et al, 2015).

**Case Study Description**

The course was CENG 4350 Municipal and Hazardous Waste. This was the second time the course has been taught at UT Tyler. In the Spring 2014 semester the enrollment was 18 students (3 graduate students and 15 undergraduate students). The course (both semesters) was taught once per week as an evening class and made use of Microsoft PowerPoint for lecture notes and the whiteboard for example problems. Due to the use of PowerPoint, this course was deemed a good candidate for iPads in order to reduce paper use by not printing the PowerPoint slides. In Spring 2015 only 5 students enrolled in the course (4 undergraduates and one undergraduate who was auditing the course). This was a much lower enrollment than expected and resulted in a low number of survey results. Students were provided an iPad for use in and out of the class for the entire semester. The Instructor discussed free applications to take notes on the tablets and for readers/writers of pdf documents.

In the Spring 2015 semester a new project was adapted into the course which became the main focus for the use of iPads in the class. In the first offering, an extra credit project was assigned where the students had to operate their own composter. Only two students completed the project. In Spring 2015, the compost project became a required component of the graded assignments and not an extra credit project. The project amounted to ten percent of the final grade. The students kept a weekly journal on Blackboard. Each week the students were required to write a description of their compost, questions/comments, and include a picture of the compost. The iPad was a venue in which all components could be done at the same time and with only one device. The Instructor commented weekly to the journal entries. The first year, Spring 2014, the students kept a typed up journal with pictures, but printed the document out at
the end of the semester. The new format lowered the amount of paper needed in the class and increased the feedback from the Instructor to the students.

Surveys were posted on Blackboard for the students. All surveys followed a 5-point Likert scale. The first week of class a pre-survey was posted to assess student background/familiarity with iPads. Then in weeks 4, 8, 12 and 14 surveys were posted to assess student opinions (and change in opinions) on iPad use (see Appendix for the surveys).

**Survey Results**

Only two students completed the pre-survey. The indication is the students had little to no experience with iPads. Unfortunately, only one student (the auditing student) completed any of the follow up surveys. This student completed the surveys in weeks 4 and 8. These results indicated that the student was neutral on whether or not iPads were helpful in learning course material. However the student agreed that he/she liked having an iPad, it was helpful to view notes and would recommend an iPad to other students. When asked two questions regarding whether or not the iPad was useful for the composting journal entries, the student responded strongly agree and agree. It can be interpreted that though the iPad was useful. None of the students completed the final survey. The final survey was extended until May 15, 2015 and an email reminding the students to fill out the survey was sent on Monday May 11, 2015.

**Discussion**

Though there were little to no survey results, other conclusions can be drawn from the project based on in-class discussions and Instructor observations. The students seemed to like the iPads for the composting project as they provided a convenient method to upload pictures and discussions to Blackboard. Using the Blackboard journal function was successful for this project. Each week the Instructor would make comments to the student entries. These included comments to bring the classroom lecture into diagnosing and improving the compost degradation. The pictures were very useful in this project as they provided visual verification of the progress of the project. In addition, it was a method to ensure degradation was occurring and to provide reasons for shortcomings.

The success of educational technology is dependent on its implementation into the classroom environment (Reid and Ostashewski, 2011) and the applications loaded onto the iPads (Hesser and Schwartz, 2013; Ravishankar et al, 2014). iPads were not required to be used in this class for any assignments. This class was setup for iPads to be used voluntarily by the students. If the iPads were required for in or out of class activities, it can be reasoned that the iPads would have been used more frequently in the class. The question of whether mandatory use would have made a positive or negative impact on the class is unanswered.

The use of iPads did not substantially lower the amount of paper used in this class. The students still preferred to print out class materials, regardless of whether or not the Instructor provided the printouts. In addition the students chose to write notes from the whiteboard onto paper instead of into the iPad. A demonstration of how to take notes onto iPads (including which free app can be used) was given. iPads can lower the use of paper, but the students need to be ready on their own to move to electronic notetaking. I think the desire to not use paper needs to be present. It is important to note that I have had students who prefer to take electronic notes regardless of
printout availability in past courses. In fact, some students take notes electronically for material on the whiteboard/chalk board, not just when PowerPoints or other handouts are used.

iPads may have been more useful in this class if the class size was the anticipated 20 students instead of only 5 students. In that case, more in-class room applications, such as real time surveys or group projects, would have made sense. In in-person discussions with students after the course ended and the students returned the iPads to the University, some students expressed an interest in obtaining an iPad for their own use. The use appeared to be for communication and other ancillary functions, but not explicitly for educational purposes.

Direct comparisons with other studies are difficult as the implementation and the courses are different. For example, some studies gave students tablets to keep for the semester while other studies evaluated providing the students with tablets for a single class session (Romney, 2013). Indirect comparisons can be useful in assessing similarities between student responses and thus several studies are summarized in the following paragraphs.

The findings in this study were similar to those found in a study by Goyings (2013). Goyings (2013) conducted a study during the Fall 2012 semester in a junior level engineering class. The 18 students in the class received iPads and an e-text version of the course textbook. A pre-attitudinal survey was administered on the first day of class and a post-attitudinal survey was administered on the last day of class. Both surveys were on a 5-point scale. When students were asked to rank the statement “Desire to use iPads in other classes”, the result was a score of about 4.3. When asked to rank the same statement at the end of the class, the results dropped to about 3.2. When asked to rank the statement “iPad will help my learning this class” on the first day of class, the results were a score of about 3.6. When asked to rank the statement “How much did iPad help your learning?” on the last day of class, the rank lowered to about 2.8. In addition, the study by Goyings (2013) held focus groups with the students. In general the students found the iPads useful for humanities courses, but a poor tool for taking notes (the use of iPads in the humanities courses was not specified). Using less paper in the course was seen as a positive aspect of iPads. At the end of the semester, the students seemed to prefer ancillary functions to course-driven functions of the iPad.

Sloan (2013) studied the use of iPads in a Systems Analysis (Computer Science) course and found that students liked the communication, playing games, note-taking and e-reading functions which were also found in this study. But, overall the students did not think the cost of the iPad was justified. Particularly, the inability to run Flash-based programs and lack of printing support were viewed negatively. Amick and Cross (2014) noted that a drawback to iPads is the cost to the student of purchasing the iPad. However, the use of etextbooks instead of traditional textbooks would offset this cost as etextbooks commonly have a savings of over 50%. In addition, transitioning to paperless saves on paper and printing costs to the University and to the students. Hesser and Schwartz (2013) estimated that 120 pages per student were saved in their one-semester laboratory class with 11 laboratory experiments.

Hesser and Schwartz (2013) taught a paper-less Honors General Chemistry I lab with 20 students and found that time was needed for students to adapt to using iPads, particularly how to write neatly onto an iPad touch screen. The authors of the aforementioned study found time was needed for instructors to setup the iPads prior to the class starting. The successful application of
iPads into the laboratory course involved choosing the right applications and spending time to explain the apps to students.

The lack of keyboards was noted as a negative aspect of iPads (Rossing et al., 2012; Goyings, 2013). Therefore, having an external keyboard attachment may increase iPad use. Maclaren et al. (2012) noted that engineering education frequently uses mathematical symbols, Greek letters, and diagrams. These aforementioned uses are not easily translated into keyboard-centric technologies, resulting in a reduced capacity for iPad use in lectures. The touch-screen can offset this disadvantage if the users are able to neatly and efficiently write on the iPad tablet.

Conclusions
Tablets are becoming more common in college classrooms, but in order to enhance teaching well-thought out plans for the incorporation of tablets are needed. Instructors need to plan which applications and which tablet will be used in advance. The tablet used is important as not all applications are available on all operating systems. This study was conducted as a pilot project to incorporate iPads into an environmental engineering course for use in and out of the classroom. There were not a lot of survey results, but from discussions with the participating students it was clear that they students liked the free iPads. In conclusion, iPads were adopted into an environmental engineering course, but the use of the iPads appeared to be mainly for ancillary functions and not explicitly for educational purposes.

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References


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**Appendix: Posted Surveys**

Surveys will be posted on Blackboard and available to every student in the class. The following will be posted on the instructions for each survey:

“This is a research study designed to examine various aspects of iPad use. Your participation is completely voluntary and you are free to stop at any time without any undue consequences. Participation or non-participation will not affect your grade. Do not place any identifying information on this survey. It is completely anonymous”.

Survey 1: 1st day of class
Questions 1 through 5 were given again in lecture week 14 (the end of the class)
Please respond to each question using the following:
5 = very knowledgeable
4 = knowledgeable
3 = somewhat knowledgeable
2 = little knowledgeable
1 = do not know at all

Question 1: To what extent are you familiar with iPads?
Question 2: To what extent are you familiar with taking pictures with an iPad?
Question 3: To what extent are you familiar with Blackboard?
Question 4: To what extent are you familiar with the journal function of Blackboard?
Question 5: How familiar are you with composting organic garbage?
Question 6: Have you previously used iPads for instructional purposes (please answer yes or no)?

Please respond to each question using the following:
5 = very helpful
4 = helpful
3 = somewhat helpful
2 = little helpful
1 = not helpful at all

Question 6: Do you expect that using an iPad in this class will aid your learning?
Question 7: Do you think that using an iPad will be helpful for note-taking in class?
Question 8: Do you think that using an iPad camera will be helpful for keeping an online journal on garbage composting?
Question 9: Do you think that using an iPad will be helpful for keeping an online journal on garbage composting?
Question 10: Do you think that an iPad will be helpful for viewing notes in typed formats (such as PowerPoint)?
Question 11: Would you recommend using an iPad to peers (students) (Please answer yes or no)?

The same survey was given throughout the semester to assess trends in the student’s opinion as the semester progresses.

Survey 2: During the semester
This same survey will be given in Lecture weeks 4, 8, 12, 14. You will have one full week to take the survey.
Please rate each statement using the following scale:
5 = strongly agree
4 = agree
3 = somewhat agree
2 = disagree
1 = strongly disagree

Question 1: Using an iPad in this class aided my learning.
Question 2: Did you use an iPad for note-taking (please answer yes or no)?
Question 3: Using an iPad helped me with note-taking in class.
Question 4: Using an iPad camera helped me keep my online journal on garbage composting.
Question 5: Using an iPad helped me keep an online journal on garbage composting.
Question 6: Using an iPad helped me view notes provided in typed formats (such as PowerPoint).
Question 7: I am glad that an iPad was provided for me.
Question 8: I would recommend using an iPad to peers (students).