AC 2012-4709: ANALYSIS OF MOBILE TECHNOLOGY IMPACT ON STEM-BASED COURSES, SPECIFICALLY INTRODUCTION TO ENGINEERING IN THE ERA OF THE IPAD

Mr. Oscar Antonio Perez, University of Texas, El Paso

Oscar Perez received his B.S. and master's in electrical engineering from the University of Texas, El Paso, with a special focus on data communications. He is currently pursuing a Ph.D. in electrical and computer engineering. Perez has been teaching the Basic Engineering (BE) BE 1301 course for more than five years. He led the design for the development of the new BE course (now UNIV 1301) for engineering at UTEP: Engineering, Science, and University Colleges. He developed more than five new courses, including UTEP technology and society core curriculum classes specifically for incoming freshman with a STEM background. Perez has eight years of professional experience working as an electrical and computer engineer, providing technical support to faculty and students utilizing UGLC classrooms and auditoriums. Perez is committed to the highest level of service to provide an exceptional experience to all of the UGLC guests. Perez strongly believes that by providing exceptional customer service that UGLC patrons will return to make use of the various services the university offers. Perez enjoys working on the professional development of the student employees at the UGLC. He shares with his student employees his practical experience in using electrical engineering concepts and computer technologies to help in everyday real-world applications. Perez has worked with the UTeach program at UTEP since its creation to streamline the transition process for engineering students from local area high schools to college by equipping their teachers with teaching strategies and technologies each summer. Perez enjoys teamwork and believes in education as a process for achieving lifelong learning, rather than as a purely academic pursuit. He currently works on maintaining, upgrading, and designing new computer classroom systems. Perez is inspired because he enjoys working with people and technology in the same environment.

Dr. Virgilio Gonzalez, University of Texas, El Paso
Dr. Mike Thomas Pitcher, University of Texas, El Paso
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Mr. Hugo Gomez, University of Texas, El Paso

Hugo Gomez has a master's degree in engineering education at the University of Texas, El Paso. He works alongside a wide assortment of faculty, staff, and students on campus to make sure their technology toolsets are up to date. Gomez oversees the International and Professional Certification Institute within the Undergraduate Learning Center. Gomez's focus is to expand the professional and technical skill sets of our students and community members to better prepare them for the world of technology today. Gomez trains over half of the student population at UTEP and as such, has been instrumental in providing the behind the scenes support to all sections of English 1311/1312, which now utilize web and movie making technologies throughout. Gomez loves his interactions with students, both as student staff and workshop attendees. His goal is to work with each individual instructor to truly understand their teaching objectives and learning outcomes so that trainings can be tailored to the specific technology needs. Gomez participated in the UTEACH summer program as a Technology Instructor in which he provided workshops on website design, movie creation and computer networking. In addition, Gomez co-taught a university 2350 class: Interdisciplinary Technology and Society, in which students learn communication skills, ethics of the use of technology, and teamwork, among other topics. Gomez presented at the Teacher Networking Technology 2010 conference, where he presented on mobile technologies and the use of Podcast Producer to help the process of creating and publishing podcasts. Gomez also participated in MaST (Math and Science Teachers Academy) delivering workshops for the students. Gomez, as well, works with the UGLC team to provide Center for Life Learning classes to assist our returning community members in keeping up with the fast-paced and ever-changing world of technology. When not preparing our students for their technology dependent future careers, he assists in the UGLC with audiovisual systems design and support as well as a professional development mentor for the UGLC student staff. Gomez believes that together we create the future of our students, in which technology skills and professional certifications are just one piece of the puzzle that will make our students not just marketable but the market leaders when they graduate.

Mr. Pedro Arturo Espinoza, University of Texas, El Paso

Pedro Espinoza received his bachelor's of science in electrical engineering degree from the University of Texas, El Paso (UTEP) in 2001 and is currently pursuing a master's of science in engineering with a concentration in engineering education. Espinoza works collectively with a team of dedicated managers that oversee instructional technology in the Undergraduate Learning Center at UTEP, a building that serves 10,000 students and faculty on a weekly basis. He leads a group of more than 30 student employees that help support a wide range of technologies and services in the building. Pedro's primary area of expertise lies within the area of computer and network support applied specifically within the educational technology environment. His responsibilities include classroom design and installation, configuration/programming and maintenance of the systems in the UGLC. Espinoza also oversees and supports high-end video conferencing systems that regularly communicate to different parts of the world. Espinoza was integral in the unique design of the videoconference rooms, of which one was featured in both an article in Campus Technology magazine and Draper's Product Guide for Visual Communications. In addition to systems support, Espinoza also teaches technology classes through several programs such the International Professional Certification Institute (iPCI) at UTEP and the UTeach Engineering Miners Summer Institute. Among some of the courses that Espinoza teaches through iPCI is CISCO Certified Network Associate (CCNA) and Apple Certified Support Professional (ACSP). Through the UTeach Engineering Miners Summer Institute, which teaches local area teachers engineering concepts and teaching strategies, Espinoza has provided workshops in both computer networking and student leadership. Recently, Espinoza has also presented at the 11th Annual Teachers Networking Technology Conference, which is geared towards K-5 educators. The presentation, "Harnessing the Power of Wikis and Ad-hoc Polling in Your Classroom through Mobile Devices," focused on best practices on using mobile devices, such as the Apple iPad, to promote student participation and collaboration through online polling and a class wiki site.

ANALYSIS OF MOBILE TECHNOLOGY IMPACT ON STEM BASED COURSES; SPECIFICALLY INTRODUCTION TO ENGINEERING IN THE ERA OF THE IPAD.

The impact of new technologies on teaching and learning engineering is important to study and understand for various reasons, including: (1) use of technology tools by students is pervasive, and (2) use of technology tools in schools and college classrooms is increasing rapidly, as new devices that balance cost, functionality and portability, shift the use of computing devices from personal purposes to mainstream course applications. We present the results of studying the impact of using one such device (the Apple iPad) on students' academic performance via a subset of course objectives for an introductory engineering course. This paper inherently focuses on student perceived value and learning impact (comprehension of learning outcomes). An iPad 1 was provided to students along with focused activities to gauge differences in comprehension of learning outcomes. Student perceived value of using an iPad 1 for a class was also measured, tested and evaluated within a learning environment featuring 21st century demographics for the science, technology, engineering, and mathematics fields. The effect of an iPad in the STEM classroom was focused on two key indicators: academic impact and student perceived value. Student perceived value was measured via a student attitudinal survey (Likert scale) completed prior to and subsequent to iPad technology utilization managed through an independent third-party testing entity. The perceived value pre survey was done prior to students having knowledge that they were going to be receiving iPads for use in the course. The assessment for the comprehension component of the study focused on three cohorts of students. All cohorts of students were taught the same way from the commencement of the semester until the time of the first course exam. This was done to limit and account for the possible variance of class grades. At the beginning of week eight, iPads were then introduced and provided for the second and third cohort of students. The usage of the iPad in class assignments was focused on maximizing the impact of student learning on the following class areas: Class assignments, homework, quizzes and exams. Variances between the cohorts were assessed as part of the second and third semester exams. Two years of results enabling longitudinal comparison are now possible. This research project has yielded data in a field that has not been previously explored within the associated demographic environment. The complete analysis on the comprehension and student perceived value have been analyzed and very interesting results that have been obtain here within this paper.

INTRODUCTION

Throughout history there have been many attempts to incorporate different technologies in the classroom.[1] Some of these technologies have seen more success than others when looked at in comparison.[2] The most commonly used classroom technologies are: PowerPoint, computer, chalkboard, web posting of materials, paper handouts, transparencies, laptops, overhead projector, classroom computer, online course management, whiteboard, online discussion groups, document cam-

era, tablet PC, streaming video, clickers, VCR, Acrobat Connect, PDA.[3] However, the impact of one of the newest technologies available to the consumer and educational markets, the Apple iPad, has currently not been researched extensively as to its effects in the classroom. While there are several ongoing research efforts to measure the impact of the iPad in the classroom, most of them are focused on the K-12 environment exclusively. This presents a challenge as currently no research exists within the engineering and science fields of first-year college students, whose demographics compare to those found at the University of Texas at El Paso (UTEP). This research specifically focuses on the impact the "iPad" has on a subset of objectives for a first year engineering class that represents the university demographics.[4] This research will measure students' perceived value of using technology (specifically the iPad) inside and outside the classroom. This type of study has not been previously done given the demographics, content, and subject matter involved. This research provides important information for the engineering and engineering education fields. The possibility exists that such could increase the academic performance of incoming freshmen and this study measures the effect on student's perceived value of the usage of new technology on academic performance; specifically the iPad.

The evolution of classroom technology is variable and the rate at which they evolve changes from device to device. A key example of such is the board. Boards have been around for a long time and have evolved into chalkboards, then into whiteboards, and then some of the functions of the boards were transferred to projectors and computers, thus creating smart boards.[3] Would the new generation of students positively perceive the impact of an iPad as a beneficial tool for their education? This research used the iPad to merge some of the most commonly used classroom technologies that were already implemented in the course into this mobile device. The previously used technologies were: PowerPoint, computers, online calendars, online notification systems, email, and online group discussions. Will the impact of the iPad on the classroom outweigh its cost in this framework? This is one of our primary questions.

MATERIALS AND METHODS

This research has been going on now for a two-year period for the UNIV 1301 Foundations of Engineering classes taught by the same instructor. The classes participating in this research consisted of similar enrollment numbers. The first class consisted of twenty-eight students; the second class had twenty-two students and the third class twenty-six students. These classes are part of a learning community. A learning community is a group of students that are enrolled in the same classes with the same instructors. In these specific learning communities all of the students were enrolled in Pre-calculus. All of the students in these classes are first semester freshmen and the class distribution represents the university demographics[5]. This reduced outside factors that influence student learning and allow the iPad as the only variable.

The materials used for this research were the following: Apple iPads (16 GB, Wi-Fi enabled only) and the teaching material already used to teach the class. This teaching material for the class consists of: a group websites created using Microsoft SharePoint, a series of PowerPoint presentations, twenty-one individual quizzes and fifteen team quizzes in text format, and several in-class active learning activities focused on teamwork engineering problem solving.

The experiments conducted to analyze student perceived value and learning impact are detailed below. As an overview of the experiments this is how they were conducted. To find out the learning impact on students with the introduction of the iPad three classes have been compared for academic performance. This was done after teaching the same material for all classes with the same weight for all of the components of the class. For the second experiment a pre-attitudinal and a post attitudinal survey were given to all of the students of the classes that used the iPads. This same procedure has been followed now for the second year. An additional note to the methodology used is the fact that students were never aware that they were being studied until the end of the semester when they filled the non-disclosure agreement. This was done to avoid the Hawthorne Effect[6].

UNIV 1301: Fundamentals of Engineering Class format

UNIV 1301: Fundamentals of Engineering is a face-to-face class that meets for three hours per week and it is a 3-hour credit class. An attendance policy was enforced, which allows no more than three absences for the entire semester. The grading areas of the class were the following: Homework, Quizzes & Projects, Exam I, Exam II, Final Exam, and a student presentation. The material covered in the class focuses on these four areas equally: Basic engineering and science concepts, math applications, entering student life activities (focused on the engineering department), and engineering professions. The material of the class was divided into 3 segments of six weeks each. One examination was given at the end of segment 1 and segment 2. Finally, after the last six weeks a final comprehensive exam was also given to all students.

Class Content research in the first six weeks

The first part of the experiment was to teach the two classes without the iPad for the first six weeks of the course and then compare their performance. This was done to generate a baseline for the differences in comprehension of content between the classes. At this point, for simplicity, the 2010 class where the iPad was not used will be referred to as “class A”, the class where the iPad was used during 2010 will be referred to as “class B” and the class where the iPad was used during 2011 will be referred to as “class C”. The same test was given to all the classes. To avoid students passing-on exams from one year to the next, students were not allowed to keep their exams. The exam used a grading scale of 0 to 100. The average of class A in exam one was 77.9. The average of class B in exam one was 74.8. The average of class C in exam one was 82.8; class A outperforms class B by 3.1 points on average, and class C outperformed Class A by 4.9 point and Class B by 8 points.

Class Content research on the second six weeks

For the second six weeks all of the students in class B and C received an iPad and class A continued on in the course without an iPad. Class B and class C were now able to check the class website both during class and all locations where Wi-Fi was available (95 percent of campus including all of the major buildings where the students take classes). Students used the class website to download class materials and upload assignments among other things. After the second six weeks

the average on exam 2 of class A was 59.7; the average for class B was **62.2, and the average for class C was 72.7. Class C** outperformed **class A** by **13** points and **class B** by **10.5** points on average.

Class Content research on the final Class Grade

For the last six weeks all of the students in class B and class C continued with the iPad and class A continued the course without the iPad. After the last six weeks the average on the final grade of class A was **83.9**, the average for class B was **80.3**, and the average for class C was **80.6**. **Class A** outperforms **class B** by **3.6** points **(.3 points taking into account the initial baseline),** and **class C by 3.3** points **(8.2 points taking into account the initial baseline)** on average on the final class grade.

Experiment 2 - Student perceived value

Two attitudinal surveys were administered during the length of the semester to each of the classes using iPads. A pre-attitudinal survey was conducted before any student knew there was a possibility to obtain an iPad for the rest of the semester. A second survey was administered at the 16-week mark (end of the semester). The survey administrators were independent from the instructor and no feedback was given to the instructor at any point in time while the class was going on. The instructor was able to see the results after the course concluded at the end of the semester and final grades were submitted to avoid any biasing from the instructor. After the class was over these two attitudinal surveys were analyzed and the results can be found in the results section below.

RESULTS

Below in Table 1 are the results of the class performance presented as a class average for each class for each of the exams administered during the semester, along with the final class average. Figures 1, 2 and 3 show the percentage grade distribution of both classes of all three exams in an overlapping manner to facilitate the comparison.

Table 1. Average academic performance of three classes

Class areas	Class A	Class B	Class C	Difference from Class A
Exam I (no iPad for all classes)	77.93	74.79	82.83	-3.14, +4.9
Exam II	59.7	62.2	72.75	+2.5, +13.05
Final Class Grade	83.9	80.3	80.55	-3.6, -3.35

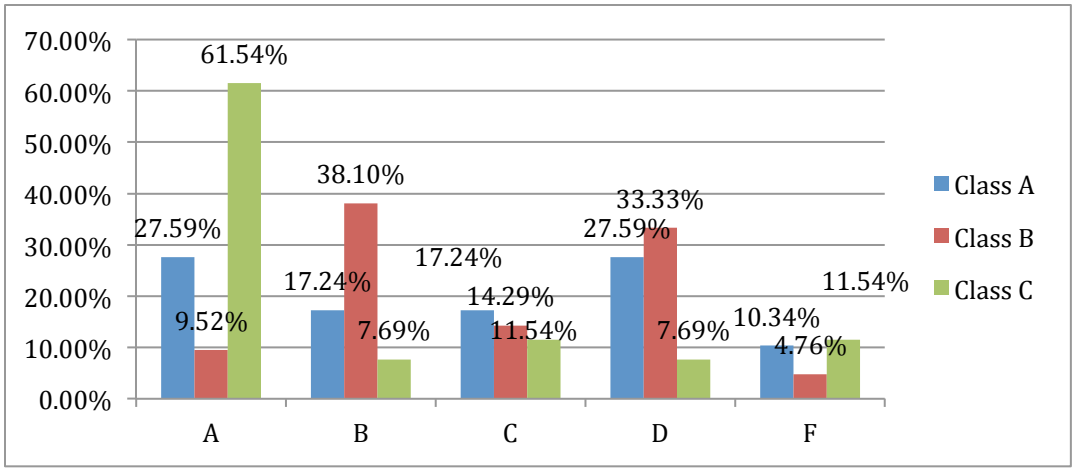

Figure 1. Exam1 student percentage grade distribution comparison

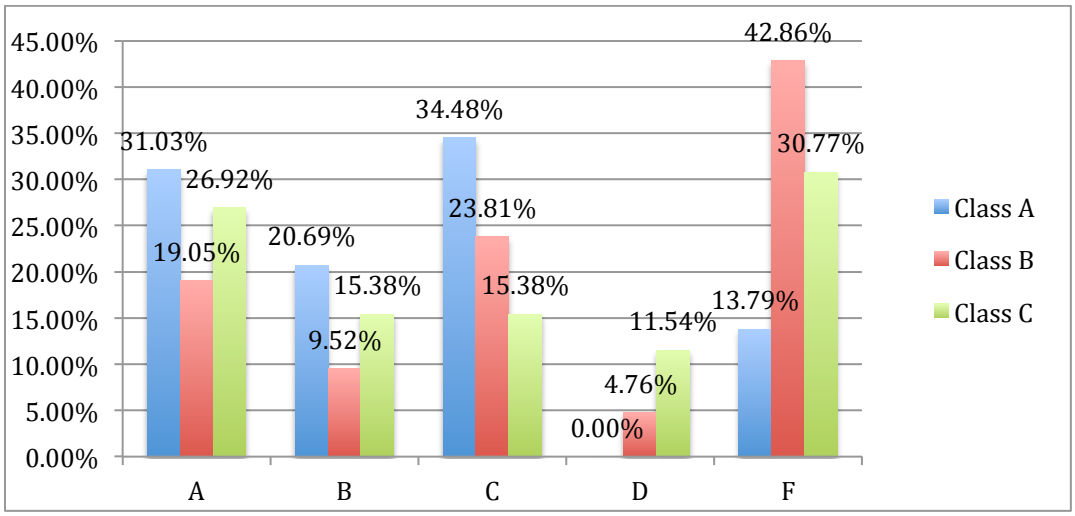

Figure 2. Exam2 student percentage grade distribution comparison

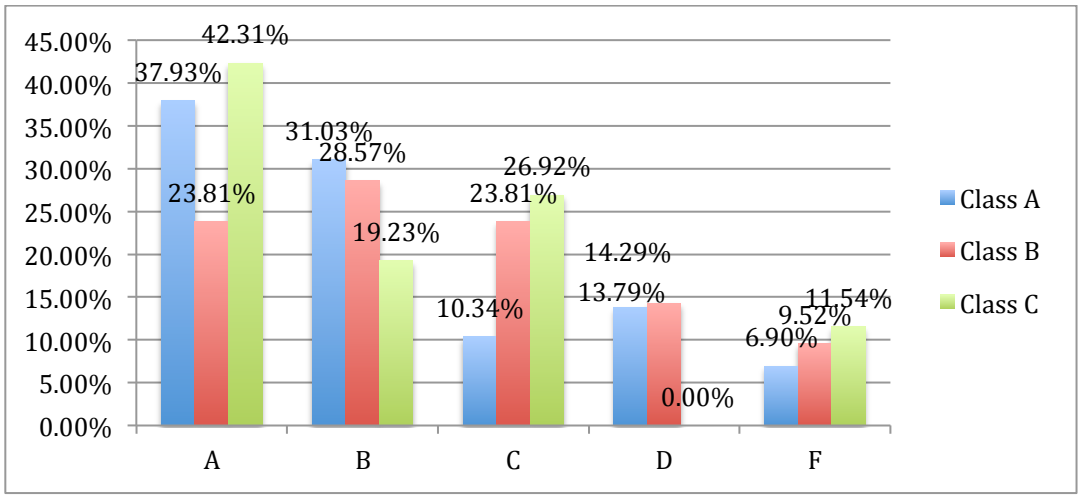

Figure 3. Final grade student percentage distribution comparison

Below tables 2, 3 and 4 show the pre and post attitudinal survey results. These results are discussed extensively in the discussion section as several important trends were discovered with this survey instrument.

Table 2. Pre Likert survey on factors of importance on learning

	Year 1		Year 2		Year 1		Year 2		Year 1		Year 2		Year 1		Year 2	
Question	Strongly agree with this statement				Somewhat agree with this statement				Somewhat disagree with the is statement				Strongly disagree with this statement			
Pre / Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Technology helps me understand concepts better:	36%	73%	74%	71%	64%	27%	26%	25%	0%	0%	0%	4%	0%	0%	0%	0%
If I was provided an iPad in this course I would use it regularly:	86%	80%	70%	71%	7%	22%	17%	25%	0%	0%	0%	4%	7%	0%	9%	8%
If we used iPads in this class; my instructor would expect more of me:	29%	40%	61%	42%	50%	33%	30%	33%	14%	27%	4%	17%	7%	0%	4%	8%
The internet is an important study tool:	79%	93%	87%	83%	21%	7%	9%	17%	0%	0%	0%	4%	0%	0%	0%	0%
I would rather have an Ebook instead of a traditional textbook:	36%	60%	48%	50%	29%	20%	30%	25%	7%	13%	13%	13%	29%	7%	9%	13%
iPads are an important technology that should be used in the classroom:	14%	73%	35%	63%	57%	27%	52%	25%	14%	0%	9%	8%	14%	0%	4%	4%
Using an iPad in this course would change my expectations of it:	43%	47%	52%	71%	43%	53%	35%	17%	7%	0%	9%	8%	7%	0%	4%	4%
Student computer labs are an important resource for me in this course:	36%	53%	87%	67%	50%	47%	4%	29%	14%	0%	4%	4%	0%	0%	4%	0%
	Was traditionally taught with lecture and textbooks				Was taught completely online				Was taught utilizing technology in the classroom on a daily basis							
I would be more willing to take a course that:	14%	13%	30%	33%	7%	27%	4%	0%	79%	60%	65%	67%				

Table 3. Pre/Post multiple choice section of survey on factors of importance on learning (percent)

		Year 1		Year 2		Year 1		Year 2		Year 1		Year 2		Year 1		Year 2	
Question		Option 1				Option 2				Option 3				Option 4			
When giving a class presentation I would prefer to:		Present verbally in front of the classroom without any type of media or presentation				Use a computer generated presentation (PowerPoint or similar)				A) Turn in a research paper instead							
Pre	Post	14	0	13	13	79	100	61	75	7	0	26	13				
If given an option to use technology in my class; I would choose to use:		A) Laptop				B) Desktop				C) iPad				D) Mobile Phone			
Pre	Post	64	40	48	42	7	0	26	13	29	53	26	46	0	7	0	0
In my future career I expect to use technology:		On a daily basis				On a weekly basis				On a monthly basis				As often as I possibly can			
Pre	Post	92	87	83	79	0	6	9	13	0	0	0	0	8	7	9	4
Using technology in the classroom is:		A) Very Important to me				B) Somewhat important to me				Not important to me				Prefer the instructor not use technology			
Pre	Post	57	93	70	70	29	7	26	26	7	0	4	4	7	0	0	0
How important is it that your instructor have a good understanding of technology:		Very Important to me				Somewhat important to me				Not important to me							
Pre	Post	86	100	91	78	14	0	9	22	0	0	0	0				
Not considering cost of materials (books, computers, etc) which course would you be more willing to take:		A) One that utilizes iPads on a daily basis in the classroom				B) One that utilizes laptops on a daily basis in the classroom				C) One that utilizes textbooks on a daily basis in the classroom				D) One that utilizes lecture and note taking on a daily basis in the classroom			
Pre	Post	43	40	48	50	50	53	39	42	0	0	4	8	7	7	9	0

Table 4. Pre/Post multiple choice section of survey on factors of importance on learning (percent)

Which class would you expect to learn more from:		A) One that utilizes iPads on a daily basis in the classroom				B) One that utilizes laptops on a daily basis in the classroom				C) One that utilizes textbooks on a daily basis in the classroom				D) One that utilizes lecture and note taking on a daily basis in the classroom			
Pre	Post	14	33	39	50	71	53	43	38	0	7	4	13	14	7	13	0
Which class would you expect to be the most expensive to take:		A) One that utilizes iPads on a daily basis in the classroom				B) One that utilizes laptops on a daily basis in the classroom				C) One that utilizes textbooks on a daily basis in the classroom				D) One that utilizes lecture and note taking on a daily basis in the classroom			
Pre	Post	50	47	35	58	29	40	43	25	14	13	17	13	7	0	4	4
If the instructor knew nothing about technology which class would you be more likely to take:		A) One that utilizes iPads on a daily basis in the classroom				B) One that utilizes laptops on a daily basis in the classroom				C) One that utilizes textbooks on a daily basis in the classroom				D) One that utilizes lecture and note taking on a daily basis in the classroom			
Pre	Post	0	20	17	25	14	20	30	13	29	7	26	29	57	53	26	33
Which instructor do you think is more knowledgeable in their content area:		A) One that utilizes iPads on a daily basis in the classroom				B) One that utilizes laptops on a daily basis in the classroom				C) One that utilizes textbooks on a daily basis in the classroom				D) One that utilizes lecture and note taking on a daily basis in the classroom			
Pre	Post	7	47	35	33	50	40	39	38	7	0	4	13	36	13	22	17
In your personal life which describes you best:		I love new technologies and tinkering with them				I am interested in new technologies but take some time to learn them				My friends usually show me how to use new technologies				I try not to use new technologies until I am forced to do so			
Pre	Post	79	100	70	75	21	0	26	17	0	0	4	0	0	0	0	8

DISCUSSION

The first result up for discussion is the fact that class B in the first exam performed 3.14 (three) points below class A, and class C performed 4.9 (five) points better than class A. The framework for this exam was exactly the same for class A, class B, and class C. This fact implies that class B and class A, if everything is maintained constant, would probably perform three points below class A; and class C would perform five points above class A. After looking at the rest of the results in Table 1 we can clearly see that class B has outperformed class A in exam II by 2.5 points and class C outperforms class A by 13.05 points. If the three-point and five-point difference without technology were taken into account, this difference for exam II would be around 5.5 for the first year of the research and 8.6 for the second year. This could be attributed to specific simple calculation

topics where the iPad was used extensively such as: unit conversion, area and volume calculations, speed, velocity distance and time calculations that were tested during exam II. Figures 1, 2 and 3 describe the student percentage distribution of exams I, II, and the final grade. These results show that the distribution after implementing the iPad technology stayed for the most part constant and that the initial 3 percent difference was the same from class A leading class B at the final class average during the first year. Interestingly, in class C the percentage of students scoring less than 70 decreased dramatically by 9.15%. Another interesting fact for class C is that the final grade average was lower than expected by 8.25 points.

After analyzing the pre and post results of the attitudinal survey for the first and second years it can clearly be seen that the students' perception of technology and learning changed after the course. The percentage change on student's perception of the usage of technology in the classroom increased in all categories as shown in tables 2 and 3 for the first year of the research. Analyzing the data of the pre and post survey we can see that "pro use of technology" in the classroom increased and was highly polarized the first year. During the second year this fact also holds true but it is not as polarized. From this attitudinal survey we can assume a high level of comfort from the student while using the iPad. This two-year longitudinal analysis also demonstrates the fact that students prefer a class that uses technology and an instructor that is well versed in technology. After the course was over the students in both year-one and year-two perceived that they have learned more because they used the iPad in the classroom. Finally, from the data on the pre survey it seems that a high percentage of students deem use of technology in the classroom very important. During these two years of researching this topic it is clear that the majority of students believe that instructors that are well versed in the use of technology, specifically iPads and laptops are more knowledgeable in their content area. Finally from the attitudinal survey as a whole and after the class was over more students agreed with the statement "I love new technologies and tinkering with them". Comments like the previous one by students come from the fact that they got to use the iPad 1 in several exercises with a learning outcome in mind. An example of this was the usage of the application "Angry Birds" to explain force, mass, angle and trajectory, initial speed, and final speed. From this analysis we can determine that new technologies can be used to engage student in learning and that students like the usage of technology in their coursework and prefer courses that use cutting-edge technologies in the classroom.

CONCLUSION

Finally, this study was conducted in a framework that represents UTEP demographics in an entry-level course in engineering. From this study we can conclude that the class average increased and was maintained 3 percent below from the class that did not use the iPad on the final class average of the first year of the ongoing research. For year two of the research, the increase on the exam II grade average was higher than during the first year. The material for exam II is where the iPad capabilities and software are at par with the content covered. A strong argument can be made that because class B started 3 points below class A, the absolute impact is an increase on exam 2 of 5.5 points for class B and 8.15 points for class C in comprehension of learning outcomes. This is attributed to the applications that were used to solve engineering problems that focus on the following topics: unit conversion, area and volume calculations, distance, time, velocity and speed calculations. Student's perceived value and learning impact of having used an iPad for the course was

very positive for both years of the ongoing research. Most of the students seem to perceive learning more in a class that uses technology. In summary, the use of the iPad maintained student's academic performance at the same level for the most part and there was a highly positive impact of student's perceived value of using an iPad in the classroom, which positively affected the classroom environment.

FUTURE WORK

Future work planned for year three of this ongoing research should expand to following areas: development of applications for the iPad on the more complex engineering topics to increase classroom performance as shown from the Exam II results. Other aspects are the digitalization of the course textbook and implementation on the iPad platform, which could greatly impact the study habits of the students. An adjustment to the study could be the implementation of the iPad in higher-level engineering classes. More work needs to be done on the lasting impacts of the concepts taught during Exam 2; i.e. does the perceived value of an iPad on specific course objectives substantially impact content retention of those concepts later in the student's academic career? As we progress in the third year of this ongoing research some questions like the following can be studied, does engaging a student with technology on a difficult learning objective give them better mastery of that content area later in the academic career? Also, how does changing the perceived value of a course with technology, impact the long-term perception of students value of essential learning objectives and their performance and mastery of them throughout their career. Does exciting students early on with technology increase the chances of them graduating due to positive first semester engagements with the content? Does mobility of content and dynamic classroom technology increase course objective retention and problem solving abilities? Another key area is how such technologies impact students on the margins of passing and not passing the class, both short and long term.

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