AC 2011-1251: THE ENGAGEMENT AND RETENTION OF ELECTRICAL ENGINEERING STUDENTS WITH A FIRST SEMESTER FRESHMAN EXPERIENCE COURSE

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The Engagement and Retention of Electrical Engineering Students with a First Semester Freshman Experience Course

Abstract

Freshman retention has been a critical issue for engineering programs over the last decade. Universities have implemented many different approaches to improve the retention of freshmen. Some of these attempts include: creating general freshman courses to give early hands-on experience to the students, utilizing student feedback to design courses, and moving the ownership and maintenance of laboratory equipment from the university to the students. In the fall semester of 2009, the Electrical Engineering program at The University of Texas at Tyler took the initiative of creating and offering a first semester freshman experience course to increase freshman retention. The rationale for creating this course was originally based on student feedback and comments provided by graduating seniors during their exit interview. A number of students expressed concerns about how late the electrical engineering laboratory experience is in the curriculum. The department took the decision to help the electrical engineering students by developing a course specially designed for their freshman year. The only preparation expected from the students is high school algebra. The purpose is to introduce the students to the different areas of Electrical Engineering such as: history of electrical engineering, electrical concepts and components, digital systems, communications systems, electronics, power systems and computer engineering. The students are also exposed to the National Electrical Code and to the tools commonly used by electrical engineering students like oscilloscopes, multimeters, functions generators, PSpice and MATLAB. In order to complement the freshman experience, practicing electrical engineers is invited to talk about their industrial experiences and a module on engineering your career is introduced. Finally, the students are also expected to attend IEEE meetings, and study the IEEE code of ethics. The intention of the course is to provide the students with a healthy exposure to professional practice and real projects in the different areas of electrical engineering.

This paper will present the data collected as a part of the course offering over two academic years, specifically split into two analysis categories. The first part of the data analysis will focus on the effect of the course on student retention, extracted from the freshman cohorts. The second part of the data analysis will focus on student surveys performed at the end of the semester. This survey was designed to measure vital components of overall course effectiveness with finer granularity, including students understanding of topics such as the role of electrical engineers and their impact on society. The data collected and analyzed over the last two years clearly shows an increase in student retention rate and student and faculty input indicates that the course has been beneficial to the BSEE program.

Introduction

Retention is a major concern in most engineering programs over the last decade. Many students decide to pursue a career in electrical engineering based on counselor advice, performance in math while others may like to work with electrical gadgets and decide that electrical engineering is the right path to pursue. However, most of these students are not exposed to the electrical engineering profession and practice thereof. Some of the students enter the program expecting to

start building circuits and programming microprocessors at the very beginning of their education. However, in most programs they face a tough time working through theoretical courses like physics and calculus. This usually results in bored and disappointed students, adversely affecting retention. The Department of Electrical Engineering at The University of Texas at Tyler, in an effort to increase the retention of their freshman students has created a new freshman electrical engineering course first offered in the fall of 2009. This course is titled "EENG 1301 – Engineering the Future – Electrical and Digital Concepts," and does not have any prerequisites. The objective of the course is to introduce freshman students to the world of electrical engineering by exposing them to different areas of specialization and give them the opportunity to work on introductory laboratory projects related to the topics covered in this course.
The University of Texas at Tyler was established in late 1996 and taught its first classes in summer of 1997. The College of Engineering initially offered two Bachelor of Science degrees (electrical and mechanical engineering) and one graduate degree (Master of Engineering), which was intended principally as a service of continuing education to practicing engineers. All students in that first cohort were transfer students; at that time, the University was an upper-division school, enrolling only juniors and seniors. The University was authorized in summer of 1997 to expand to a 4-year institution and began enrolling freshmen and sophomores in fall of 1998. This necessitated the development of appropriate freshman and sophomore courses in the BSEE and BSME programs including which had previously not been offered by the University. The BSEE program has been ABET accredited since for the last two cycles.

One of the major observations from the senior survey, which is a part of the ABET Continuous Quality Improvement process, was that the BSEE curriculum needed early and frequent hands-on experiences, where the students actually feel that they are building something that worked. Two years have passed since this course was implemented. The data collected during these two years will help to show that the course has satisfied its mission, and is working as expected. It is the opinion of the faculty that the implementation of the course was one of the best curricular changes in departmental history.

Past Approaches

The addition of a first year course, trying to address retention issues is not something new or particular about any university. Several programs have implemented freshman courses in which a broad introduction to engineering and some hands on experience is offered[1-4]. Some programs utilize student feedback and program outcomes to design introductory courses[5,6], some have decided to move the ownership and maintenance of laboratory equipment from the university to the students, thereby giving them the feeling of being vested in the program[7]. Even some programs have studied how the retention is affected when an introductory course is not offered at the right time in the curriculum[8]. Retention of freshman students has been something happening from a long time and a perfect solution has not been found for this problem. Many universities have tried different approaches trying to improve the retention and performance of their freshman students. The main problem with the high school students entering college is that most of them are not prepared to start a life as a college student. In the following paragraphs, some of the approaches used to improve the retention of freshman students are summarized.

The most common approach is the introduction of a first year freshman course[1-4, 9-13]. The question behind this approach is: "What should be the content of this course". Some universities address this question by teaching problem solving skills, complex numbers and matrix

operations, PSpice and MATLAB, Communications Skills, Group Work, and by illustrating the different areas of electrical engineering. Other universities decide to have inside and outside classroom activities, teaching engineering problem solving, and have project designs.

Another approach followed by other universities is the creation of seminars that will provide the students with useful skills and knowledge about engineering[14-15]. For example, students are taught the basic survival skills: How to study, how to take notes and how to manage time between school obligations and social obligations. This approach has proven successful to quickly adapt the students to the college life.

The creation of mentoring programs[16-17] seems to be another option to these problems. The main draw back from this approach is the amount of time that needs to be invested and that it also requires a lot of resources, because either a faculty will be highly involved or students need to be hired for these mentoring positions. However, this option has proven to work at some extent and improved the performance of student.

Finally, there have been non conventional approaches trying to address retention. Some examples of these are the inclusion of freshman students to capstone design project[18], and the use of science of science fiction films and literature to help illustrate many common engineering concepts[19].

Course Structure

Two years have passed since "EENG 1301 – Engineering the Future – Electrical and Digital Concepts" was introduced in the fall of 2009. All freshmen electrical engineering students were signed up for the course. The course was composed by two lecture hours and three hours of laboratory. To make the course more dynamic for the students a single professor was not assigned to the course; instead, the lectures and laboratories were divided between the faculty members of the department. Each professor was assigned to give lectures and laboratories related to his area of expertise or to advanced courses taught by the professor. This creates the perfect opportunity for each of the professors to interact with the student and encourage them to stay on the program by talking about advanced courses and the different areas in which they could specialize.

The lectures were taught assuming that the mathematical background of the students was at the level of high school algebra. As a result, some of the concepts presented to the students were lowered in terms of the math required and the level of abstraction, but the general concepts and applications were still presented to the students. Furthermore, to increase the exposure to the profession of electrical engineering, speakers were invited to talk with the students about their experiences and the importance of electrical engineering outside the school. To wrap up the semester the students were given a final project based on a simple circuit that could be applied to real life. By this point in the semester, the students have acquired enough knowledge to understand the basic functionality of the circuit. Also, a basic description of how the circuit works is provided to the students. The students were asked to create a working prototype on a breadboard, once their prototype is working. They were asked to design the layout of a PCB and by using a LPKF milling machine create their own PCB for their final design.

The course lectures were divided into the following eleven main topics:

1. History, Dimensions and Units
2. Electrical Concepts and Components
3. Digital Systems
4. Electrical Engineering Tools and Communication Systems
5. Fiber Optics
6. Electronics
7. Power Systems
8. National Electrical Code
9. Data Analysis
10. Computer Engineering
11. Ethical Issues in Engineering

A main consideration while preparing these topics was that the focus of the course was not to make the students understand all the details from each topic. Instead, the objective was to expose the students to these topics by keeping in mind that most of them do not have knowledge on calculus and differential equations. Based on the amount of exposure that the student will receive on each of the topics, either two or three weeks were allocated for each topic. The schedule used in this course is shown in Table 1. In addition to the two hours of lectures per week a three-hour laboratory was preformed once a week. This laboratory was directly related to the topic covered during the same week; in essence, the purpose of the laboratory was to apply the knowledge provided during the lecture and at the same time give them the opportunity to get some hands on experience related to the topic, so they can realize how those concepts are applied outside the lecture. To conclude the semester, teams of no more than four students were created; each group could select one project from a pool projects previously reviewed by the faculty members. The list of projects selected for the fall of 2010 is shown below:

- Audio Mixer
- Battery Powered USB Charger
- Electrocardiograph Amplifier
- Sine, Square, Triangle Generator
- Electronic Stethoscope
- Model Sports Car Lighting System
- Telephone Bug
- AM Radio
- Random Number Generator
- Siren Generator
- Spying Microphone
- Voice Changer

The teams were asked to build a prototype of the circuit on a breadboard. This gave the student the opportunity to apply the knowledge acquired during the semester about how to use the equipment and how to build a circuit. Once the prototype was fully functional and ready for production, they were asked to create a PCB layout based on their prototype. Using their layout and the LPKF milling machine available at the department, the students were able to create their own PCB in which they placed the components to obtain a final working product. The student

teams were asked to create a poster presentation the day on the day of the final examination to present their product to the faculty members.

The content of the course was designed by keeping in mind the following course objectives:

1. List and describe contributions of the electrical engineering profession to society
2. Apply Ohm's Law and Kirchhoff's Laws to simple dc circuits.
3. List and describe the basics of an electric power system
4. List and describe commonly-used signals, electronic and communication systems.
5. List and describe the basic structure of a personal computer and of a computer networking system.
6. Make measurements of voltage, current, and resistance with a digital multimeter.
7. Make measurements of voltage and frequency using an oscilloscope.
8. Write a laboratory report in a simple memorandum format.
9. Create and present an oral/visual presentation of laboratory results.
10. Perform basic computations and solve a system of simultaneous linear equations with MATLAB
11. Perform dc analysis with PSpice or other circuit-analysis software

These course objectives were decided by the faculty of the department.

Finding an adequate textbook for the course was a great challenge. The faculty considered several textbooks for this course. The main problem that was encountered from all the books reviewed was that any of these books could cover all the required topics for the course. Some of the books covered the topics using math that was too advanced for a freshman. Some other books were not at the desired level. In summary, there was no book available that will satisfy all the objectives of this course.

After discussing by days about the best book for the course it was decided to try to create a custom textbook from Pearson[20]. The major advantage of the approach was the flexibility provided by including only the necessary topics and limiting the cost of the book. The custom book created for this course consisted of the following chapters:

Table 1. Chapter break-down of the custom book used for EENG 1301

Author	**Title/Chapter**
Fleddermann/Bradshaw	Electrical and Computer Engineering Specializations
Hagen	Dimensions and Units
Fleddermann/Bradshaw	Electrical Concepts and Components
Hagen	Electrical Circuits
Fleddermann/Bradshaw	Active Components and Integrated Circuits
Fleddermann/Bradshaw	Engineering Tools for Electrical and Computer Engineers

A second textbook on the National Electric Code (NEC) was added as a reference to inculcate a sense of belonging to the profession and the electrical engineering major. To evaluate the success of the course, the students were asked to fill out a survey at the end of the semester in which they evaluate the effectiveness of the course to increase their understanding about electrical engineering and the profession.

Course Evaluation and Impact

The inter-year retention rate for the BSEE program for the 2008-2009 academic years, based on data before the introduction of the freshman electrical engineering course was 54.8%. In the first offering of the course, 16 students completed and passed EENG 1301. Only 4 of them have dropped out of the program and the remaining 12 students are still actively enrolled. This represents a 75% retention rate from freshman years to the sophomore year and is a significant improvement.

The course has been offered for two years, and enough data has been collected to analyze the impact of the course through a student survey with questions outlined in Table 3. The figures in this section represent survey histograms with overlaying Gaussian distributions corresponding to the survey responses. The mean rating for each question is measured on the horizontal axis, while the amplitude of the normal distribution is represented on the vertical axis.

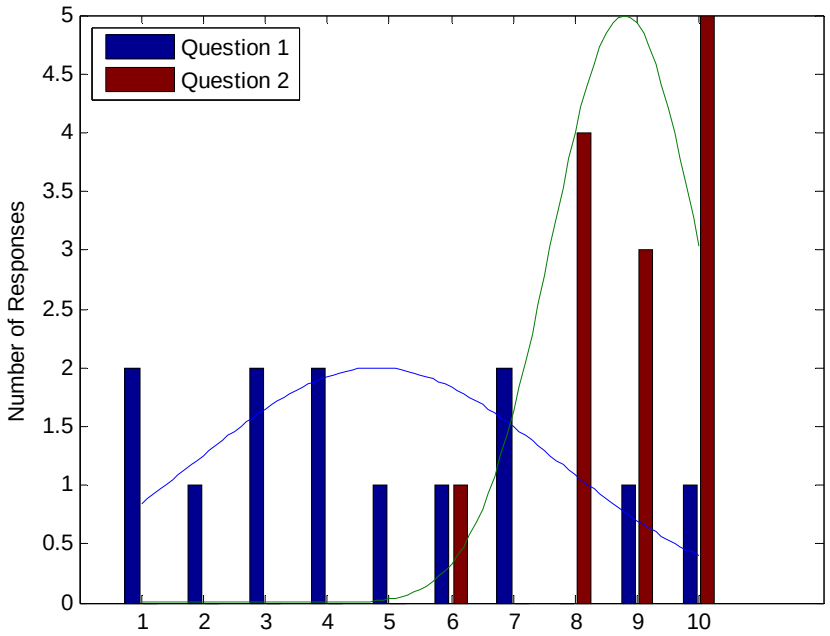

Figure 1. Rating of the knowledge (horizontal axis) about the professsion of electrical engineering before and after the course for fall of 2009. The dark line represent their knowledge before the course and the light line respresents their knowledge after the course.

The students were given a survey composed of sixteen questions to evaluate the success of the course. The survey is given to the students the last week of the semester during class. The professor is required to leave the classroom while the students fill out the survey. Since some of the questions are reflective in nature, in the following years the authors will seriously consider modifying the survey methodology to include two surveys: one at the beginning of the class and one later. One of the major difficulties with this approach is to quantify and measure items like “knowledge of the area of electrical engineering” at the beginning of the course. The first six questions of the survey are committed to obtaining information about the amount of knowledge that the student possessed about electrical engineering before taking the course, how sure they were about becoming electrical engineers and how this course has improved that knowledge and

their thoughts about becoming an electrical engineer. The survey questions represented by the graphs are listed below with a complete listing in Table 3:

1. Your knowledge about the electrical engineering profession before taking the course
2. Your knowledge about the electrical engineering profession after taking the course?
3. Your confidence about becoming an electrical engineer before taking the course
4. Your confidence about becoming an electrical engineer after taking the course
5. Your knowledge about the areas within electrical engineering before taking the course
6. Your knowledge about the areas within electrical engineering after taking the course

The following three questions are designed to obtain information about how much this course has helped them to understand more about the different areas within electrical engineering and the tools used. The remaining questions are focused to obtain useful information about how the course is helping them on other courses and to feel more as part of the department of electrical engineering. The summary of the data obtained from fall of 2009 and fall of 2010 can be observed in Table 2.

Figures 1 and 2 represent the data obtained from questions one and two from the surveys of 2009 and 2010 respectively. It can be clearly seen that the knowledge about the electrical engineering profession has been highly increased thanks to the course.

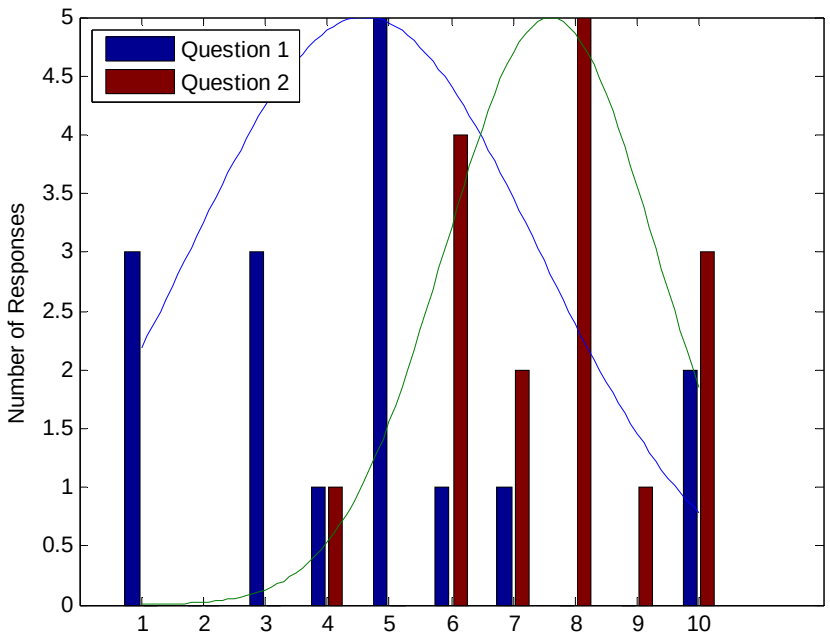

Figure 2. Rating of the knowledge (horizontal axis) about the professsion of electrical engineering before and after the course for fall of 2010. The dark line represent their knowledge before the course and the light line respresents their knowledge after the course.

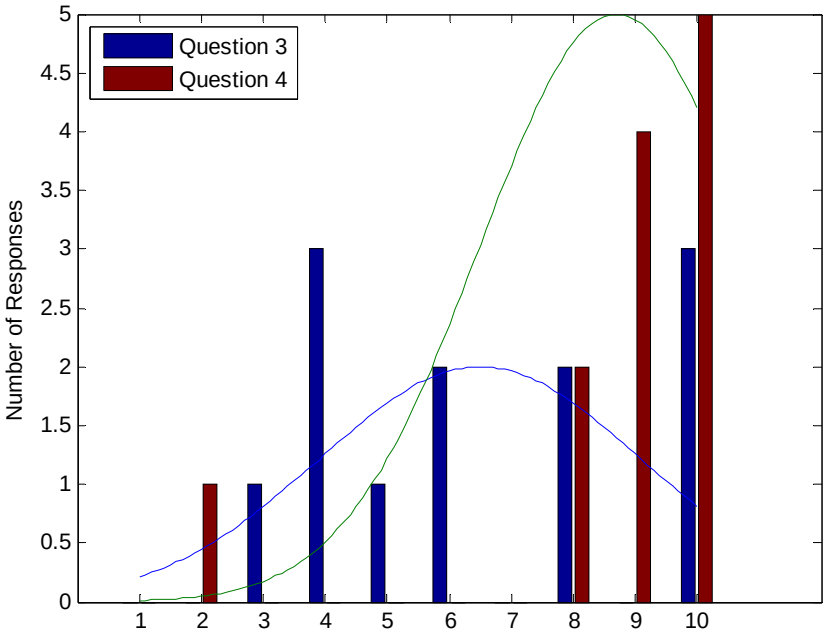

Figure 3. Rating of their confidence (horizontal axis) about becoming elecrical engineerings before and after the course for fall 2009. The dark line represent their confidence before the course and the light line respresents their confidence after the course.

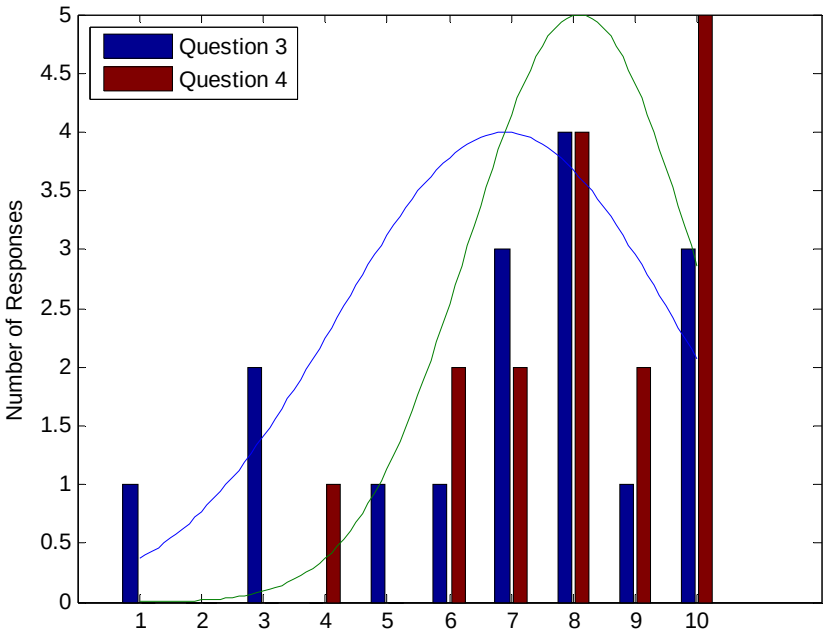

Figure 4. Rating of their confidence (horizontal axis) about becoming elecrical engineerings before and after the course for fall 2010. The dark line represent their confidence before the course and the light line respresents their confidence after the course.

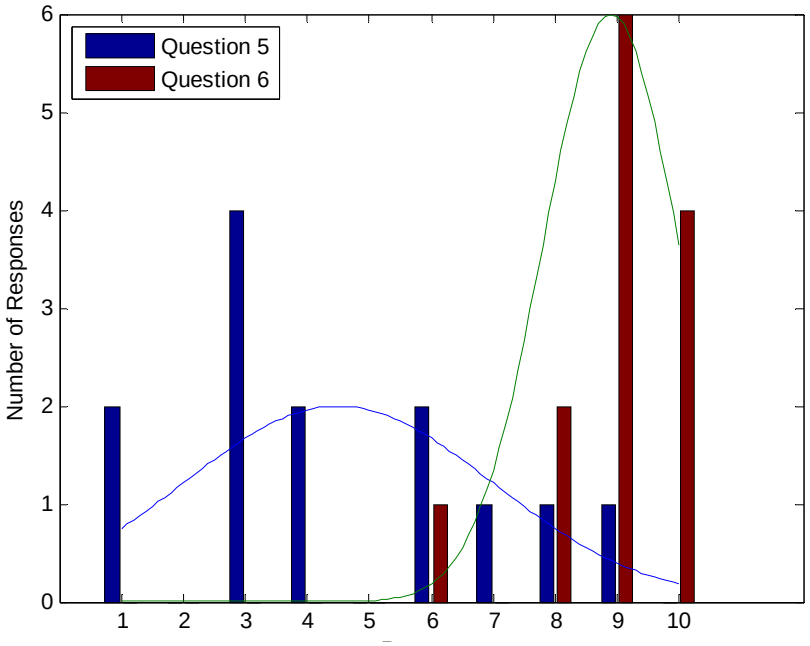

Figure 5. Rating of the knowledge (horizontal axis) about the areas within electrical engineering before and after the course for fall of 2009. The dark line represent their knowledge before the course and the light line respresents their knowledge after the course.

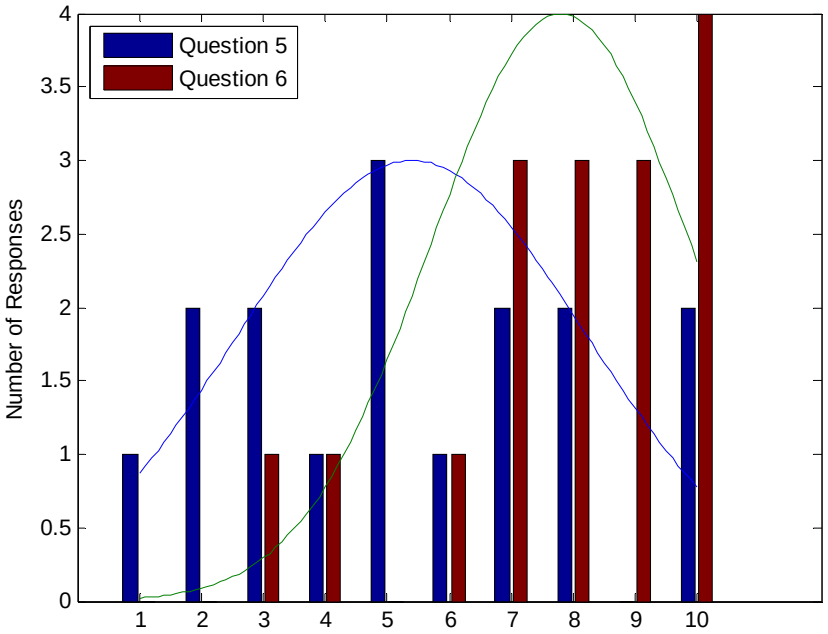

Figure 6. Rating of the knowledge (horizontal axis) about the areas within electrical engineering before and after the course for fall of 2010. The dark line represent their knowledge before the course and the light line respresents their knowledge after the course.

Figure 3 and 4 represent the data obtained from question 3 and 4. The objective of these questions is to assess the confidence of the students to become electrical engineers before and after this course. It can be clearly seen from these figures that the students feel more confident about their decision of becoming electrical engineers.

Finally, figures 5 and 6 represent the data obtained from questions 5 and 6. The objective of these questions is to assess how much knowledge the students acquired from the different areas of electrical engineering. It is evident that the course is helping the students to understand more about the different areas of electrical engineering, helping them to realize a more informed decision about what they want to do once they graduate.

The survey data clearly shows that the students are more engaged and enthusiastic about their profession as a result of the introduction to electrical engineering course.

Conclusions

The Department of Electrical Engineering at The University of Texas at Tyler, in an effort to increase student retention, created an introductory electrical engineering experience course that is offered during the first semester of the freshman year. The course has no prerequisite other than high school algebra and covers the following topics: History, Dimensions and Units; Electrical Concepts and Components; Electrical Engineering Tools; Introduction to Digital Systems, Communication Systems, Fiber Optics; Electronics, Power Systems and Computer Engineering; National Electrical Code; Data Analysis and Ethical Issues in Engineering. The faculty designed their own custom textbook for the course, after surveying the available textbooks in the area, and have also designed appropriate laboratory projects to meet course learning objectives. In addition, the students attend IEEE meetings and invited lectures from practicing engineers.

Two years have passed since "EENG 1301 – Engineering the Future – Electrical and Digital Concepts" was introduced into the BSEE degree plan. Preliminary data shows that the retention rate from freshman to sophomore years has improved from 54.8% to 75%. The survey data also clearly indicate that the retained students are more engaged and enthusiastic about the profession. It can be safely concluded that the impact of this course is very positive. Future work will involve longitudinal data collection and tracking of retention rates over multiple years. The student and faculty comments indicate a demand for increasing the number of laboratory projects and this has been discussed by the faculty and is currently being strongly considered for the next offering of the course in the fall of 2011.

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Table 2. Semester schedule for the freshman electrical engineering course

WEEK	TOPICS COVERED	LECTURE (T)	LECTURE (R)	LABORATORY
1	Introduction		Introduction - EE Areas	
2	History, Dimensions and Units	History of EE	Dimensions and Units	Movie: Empire of The Air
3	Electrical Concepts and Components	Electrical Concepts and Components	Electrical Concepts and Components	Circuits - Breadboard, Resistor codes, Power Supply
4	Electrical Concepts and Components	Electrical Concepts and Components - Applications	IEEE Meeting	EE Lab Instruments - Multimeter, Scope, Function generator
5	Digital Systems	Digital Systems	Digital Systems Applications	Basic Gates
6	Engineering Your Career	Engineering Your Career	**Invited Talk**	
7	EE Tools, Communication Systems	EE Tools	History of Communication Systems	EE Tools - pSpice
8	Fiber Optics	Fiber Optics	Communication Systems Applications	Fiber Optics Lab
9	Electronics	Electronics	Electronics - Applications	Basic Electronics Lab - Soldering and Project
10	Power Systems	Power Systems	Power Systems - Applications	Basic Power Systems Lab - Motors, Generators
11	National Electrical Code	NEC	**Invited Talk**	NEC
12	Data Analysis	Data Analysis - Graphing	Data Analysis - Statistics	Introduction to Matlab/Simulink
13	Computer Engineering	History of Computer Engineering	Computer Engineering Principles	PCB Layout Software
14	IEEE Meeting	IEEE Meeting	**Thanksgiving Holiday**	
15	Computer Engineering	Computer Engineering Applications	**Invited Talk**	PCB Production
16	Ethical Issues in Engineering	Ethical Issues in Engineering	Wrap-Up	

Table 3. Summary of the student survey responses Fall 2009 and Fall 2010

	Fall 2009			Fall 2010		
Rate the following from Low to High	**High**	**Low**	**Avg.**	**High**	**Low**	**Avg.**
1. Your **knowledge** about the electrical engineering profession **before** taking the course	10	1	4.8	10	1	4.6
2. Your **knowledge** about the electrical engineering profession **after** taking the course?	10	6	8.8	10	4	7.6
3. Your c**onfidence** about becoming an electrical engineer **before** taking the course	10	3	6.5	10	1	6.9
4. Your c**onfidence** about becoming an electrical engineer **after** taking the course	10	2	8.7	10	4	8.1
5. Your knowledge about the **areas within electrical** engineering **before** taking the course	9	1	4.5	10	1	5.4
6. Your knowledge about the **areas within electrical** engineering **after** taking the course	10	6	8.9	10	3	7.8
7. How much has EENG 1301 helped you decide upon an area of specialization within electrical engineering?	10	2	7.5	10	5	8.3
8. How much has EENG 1301 helped you understand the fundamental principles of electrical engineering?	10	7	8.9	10	4	8.1
9. How much has EENG 1301 helped you understand the tools used in electrical engineering?	10	6	8.6	10	4	7.9
10. How much has EENG 1301 helped you during the current semester?	10	7	8.8	10	3	7.1
11. How much will EENG 1301 help you in the future?	10	5	8.9	10	4	8.4
12. How much has EENG 1301 helped you get in touch with the faculty members of the department of electrical engineering?	10	7	9.5	10	3	8.5
13. Rate the lectures in the course	10	8	9.5	10	5	8.1
14. Rate your laboratory experience in the course	10	8	9.5	10	5	8.4
15. Rate the exposure to professional societies like IEEE in the course and the invited talks by practicing engineers in the course	10	5	8.8	10	4	8.0
16. Would a three-hour lab only course (no lecture) be a preferable format for this course?	10	1	5.0	10	1	7.3

Students with anxiety disorder display a passive attitude in their studies such as | Find, read and cite all the research you need on ResearchGate.Â and low academic performance among engineering students, with significant correlation (p=0.000) and the correlation coefficient. is small with r=-.264. Large of sample size required to strengthen the coefficient correlation was suggested for further research.Â anxiety conditions that are experienced during study process and could be disturbance of academic performance. Study anxiety has two dimensions include physiological arousal and cognitive anxiety. 2.2. Study Anxiety upon Academic Performance. The first semesters of an engineering curricula focus on developing a solid theoretical basis in Mathematics, Physics and Programming before becoming immersed in practical projects. Therefore, first-year engineering students usually struggle to visualize the practical applications of their studies. Advancing towards an educational model based on competencies, the following workshop was an effort to increase engineering studentsâ€™ engagement and to launch their development at a first stage.Â The students enjoyed the experience and realized the main differences between the engineering disciplines involved according to their application in this practical example.Â achievement, student retention and quality on skills for. Electrical engineering is an engineering discipline concerned with the study, design and application of equipment, devices and systems which use electricity, electronics, and electromagnetism. It emerged as an identifiable occupation in the latter half of the 19th century after commercialization of the electric telegraph, the telephone, and electrical power generation, distribution and use. These student engagement strategies can help improve student motivation, student learning, progress and achievement as well as overall learning outcomes.Â Experiential learningâ€”when students learn from reflecting on their real-world learning experienceâ€”is a further development of this, and is an effective teaching strategy. 11. Social media: Potential uses for social media include sharing relevant content, posting instructional videos on YouTube and facilitating ongoing discussion groups. However, strict guidelines for use must be put in place and enforced. Student engagement strategies for assessment.Â Many learners enter university without proper study skills, and first-year students can benefit from the structure of mandatory attendance. Recent papers in Student engagement and retention.Â While many Student Support Services do great work amidst, what some have called, the shifting paradigm of higher education, the time has come for urgent reflection on how best to support students as both consumers and learners in our more.Â The majority of higher education institutions in the United States offer learning communities (LCs), which have been found to be effective for improving course success and persisting to the next semester.Â LITERATURE REVIEW First-generation students are less likely than their counterparts whose parents have more education to be prepared academically for postsecondary education and when enrolled are less likely to succeed (Warburton, Bugarin, and Nunez, 2001).