Paper

Increase Retention Rates in Computer Science and Engineering with a Wireless Classroom at UPRM

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Abstract *¾ Some factors that discourage off many students from continuing studies in the field the chose include: passivity of students in the classroom; emphasis on competition for grades rather than on cooperative or team learning; delayed or inaccurate assessment of students understanding, and instructors limited feedback as to whether students really comprehend what is being covered in lecture. Principal objectives of this project are to increase retention rates and academic performance in Computer Engineering, and Computer Science students by redesigning Algorithms and Computer Programming a second year course identified as a gatekeeper that is required for all engineering students, including Computer Engineering and Computer Science. These will be accomplished by bringing technology to the classroom, guiding professors in effective teaching methods and uses of high-tech classroom, and providing students with a learning atmosphere that enables the development of strong and fundamental academic skills. The key elements of the proposed reform are: emphasis on student-centered learning, where lectures are minimized and substituted with active inquiry activities, interactive demonstrations and cooperative learning, complemented by accessibility of the course material on the Internet. Classes must also provide activities to engage all type of students and allow time for them to self-assess and reflect on their own learning using specialized teaching software in the wireless classroom.*

Keywords ¾ Teaching strategis, wireless classroom, education research.

INTRODUCTION

The General Engineering Department (GED) is mainly responsible for most of the academic offerings in engineering during the first three years of study. Therefore, the centralized efforts to retain our students takes place within the GED. The support services that GED offer students include the freshmen orientatation week, academic councelling and the main engineering computer center (CCI).

One of the causes for low retention rates is the lack of pre-college career orientation. An enthusiastic and pro-active approach for recruiting and enhance retention of engineering students has been the Pre-College Engineering Program (Pre-Engineering) offered by the College of Engineering at the University of Puerto Rico, Mayagüez (UPRM). This program consists of a two-week summer-residential program to introduce talented high school students to a career in engineering. The Pre-Engineering Program has been sponsored by the National Science Foundation, the Puerto Rico Alliance for Minority Participation and private industries like Hewlett-Packard, Xerox Corp., Honeywell, among others. This Program also helps to increase diversity since 99.9% of our population has Hispanic origin, 85% of the participants have come from low-income families, and 50% of them are female.

Many programs exist at the UPRM where high-tech industry is involved with our engineering programs. Among them we can mention the PasCOR project and the PR-EPSCoR [1]. The PR- EPSCoR strategic plan sought to strengthen the Island's research environment, infrastructure, and human resources to promote a strong collaborative link between academia and industry so that Puerto Rico would be able to sustain and provide support for its economic development. As a result of EPSCoR and other human resource development initiatives, the number of doctoral degrees in science, mathematics and engineering granted to Puerto Ricans doubled in the five-year period of the first phase and has continued to increase substantially. The Industrial Affiliates Program (IAP) in the Electrical and Computer Engineering Department [2] is another example of the strong commitment the high-tech industry has with our Institution. Fourteen companies are currently supporting the IAP offering creative technical experience that complements the UPRM strong Electrical and Computer Engineering curriculum. Cooperative Education Program (COOP) is a very popular alternative among our students. COOP students alternate between work and study periods so that they benefit from learning opportunities available in the industry, business and government. The University of Puerto Rico shelters the Industry University Research Consortium (INDUNIV) [3]. INDUNIV links the chemical industry with our students and professors in the research projects it supports. Also, UPRM is one of the three key components of the Techno-economic Corridor, an industry research and development initiative of the government of Puerto Rico. The role of the UPRM as a Corridor element is

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to develop future researchers and engineers, and to provide technical support as well as the incubator for new technology.

Even tough we are considered the University graduating more Hispanic students [4], our biggest challenge in recruitment is that we are competing with the best universities in the US for the top high school graduates in Puerto Rico. One of the retaining challenges is a result of the heterogeneity in aptitude and preparation of the student, many of whom have poor basic academic skill such as problem solving, analyzing, synthesizing, using critical thinking and communicating ideas effectively orally or by writing. Students with talent but poor academic skills in a teaching atmosphere that do not encourage them to develop their potential are most likely to fail courses, change careers or drop out. Traditional teaching methods such as large lectures format and conferences have been responsible for low retention and high failure of students pursuing science and engineering majors [5, 6]. Some of the features that discourage off many students from these majors include the following:

- Failure to motivate interest in the content by establishing its relevance to the students' lives and personal interests.
- Relegation of students to almost complete passivity in the classroom (like taking notes without thinking deeply).
- Emphasis on competition for grades rather than on cooperative or team learning.
- Focus on algorithmic problem solving as opposed to conceptual understanding.
- They receive no immediate or accurate assessment of their understanding, leading them (often wrongfully) to believe that they understand all that is being presented.
- Instructors have limited feedback as to whether students are really grasping what is being covered in lecture. The lecture moves forward regardless of student comprehension.

Research indicates that one of the reasons for this to happen is that professors are more likely to show a strong content knowledge of their particular academic discipline, but lack training in the most effective teaching methods to transmit their knowledge to students [7]. Therefore, the principal objectives of this strategy are to increase retention rates and academic performance in electrical and computer engineering, and computer science students. These will be accomplished by bringing technology to the classroom, guiding professors in effective teaching methods and uses of high-tech classroom, and providing students with a learning atmosphere that enables the development of strong and fundamental academic skills. The most effective strategies already implemented for recruitment and retention are the Pre-Engineering program, described above, and the development of the UPRM Center for Professional Enrichment (CEP). The CEP offers two to four hours lectures and workshops to introduce professors to modern teaching techniques. The professors earn credit for the courses taken.

PAST EFFORTS IN REDESIGNING COURSES, STRATEGIES USED & RESULTS

During last year another National Science Foundation sponsored project, under the Course Curriculum & Laboratory Improvement Program (CCLI), has been under development at the Electrical and Computer Engineering Department. Lionel R. Orama and Efrain O'Neill are redesigning courses in energy systems engineering to introduce laboratory practices within class lectures. The idea is to help students understand fundamental and advanced concepts in their field by hands-on experiences in a cooperative learning environment.

Redesigning Linear Algebra, Robert Acar tested a method conceived by Dubinsky and his collaborators [8]. Students worked in groups, used material posted on the web [9], and used extensively the computer, as the activities were based on using ISETL (Interactive Set-theoretic Language). Results were mixed – for one thing, the students were not expecting to have to spend so much time on work outside of class periods. However, most of them were considerably more engaged than when teaching the course the traditional way. Interviews were given, to be followed by another round in future, and this will give us a better idea of the success of this method.

Redesigning, Intro to Programming, Ana C. González-Rios and graduate student José Peréz looked at what other Universities (University of Virginia and Northwest Missouri State University) were doing and developed their own approach to their particular student population. They perceived a need was to develop an active learning environment where students learn by doing rather than just by listening. Of the three conference hours, 2 or 1 hour were offered in a close laboratory with desktop computers, lecturing integrated environment. In this environment the instructor typically presents a formal lecture to introduce a new concept and last from 15-25 minutes. On some topics the lecture notes are made available in the internet [10]. Then, students work on a related laboratory exercise for the rest of the class period, while the instructor gives one-on-one mini-lectures to individual students as the need arises. For this purpose, the physical setup of the classic lab is not ideal and there is no easy way to introduce cooperative learning. The remaining hour is spent in a traditional classroom. It is difficult for the instructor to evaluate each student during the lab activity, and it is not until the written examination that the instructor will know how the student is doing. It is necessary to have ways to evaluate students constantly in order to determine their understanding of the material. The approach implemented has helped reduced the number of W and increased the number of C, however the instructors feel

that the students who benefit are mostly those who have clear academic goals.

Recently, systemic efforts have been made to reform science and mathematics postsecondary education through the Alliance for Minority Participation Program and the Puerto Rico Collaborative for Excellence in Teacher Preparation, both sponsored by the National Science Foundation. These initiatives provide the foundation for the reform of future science and mathematics teachers and the re-training of the professors who prepare them. Carmen Bellido is currently the evaluator of their effectiveness in UPRM. The reform promotes the preparation of professors in effective use of multiple educational techniques in their teaching practices that have proven to be effective in improving students academic performance and retention [11]. However, these initiatives are not directly impacting the computer science or engineering programs of our institution because the primary focus of the funding agency is the science and math majors program. Currently in our campus, two identified gatekeeper courses: Pre-calculus and Calculus are impacted by research initiatives (funded by the Federal Education Department) in which the students have to take weekly quizzes in computer labs through the Internet to improve their academic performance. Those projects affect those engineering and computer science students that happen to take the courses, but the reforms are not meant to change the way the courses are taught, and neither impact the engineering or the computer science faculty.

CRITERIA USED TO SELECT THE GATEKEEPER COURSE TO BE REDESIGNED

Algorithms and Computer Programming is a gatekeeper course that will undergo the redisigning process. This is a second year course required for all engineering students, including Computer Engineering and Computer Science. Table 1 shows the students per term enrolled in the gatekeeper course. Algorithms and Computer Programming includes the development of algorithms and their implementation in a structured high-level language (C Language). The typical rate of failure in this course has been approximately 20% for the engineering students and 60% for the computers science students in the last three years.

This course is a gate for other courses in every engineering program. The following list shows all the courses by program that require Algorithms and Computer Programming:

- Chemical Engineering - Materials & Energy Balances, Computer Simulation of Processes & Units, Equilibrium Stage Processes
- Civil Engineering - Surveying II, Mathematical Methods in Civil Engineering
- Electrical Engineering - Numerical Analysis, Electrical Systems Analysis II, Logic Circuits
- General Engineering - Computer Aided Graphics
- Industrial Engineering - Computer Based Information Systems, Probability and Statistics, Real Time Process Control
- Mechanical Engineering - Numerical Analysis, Heat Transfer
- Computer Engineering - Advanced Programming, Data Structures, Programming Languages, Operating Systems, Artificial Intelligence
- Computer Sciences - Mathematical Analysis, Numerical Analysis I, Lineal Algebra, Differential Equations, Introduction to Computers II, Programming Languages, Data Structures

From the above list, the authors has found that the most intriguing course is Advanced Programming. Advanced Programming is the gate for many Computer Engineering and Computer Science curriculum courses. The failure rate of this course has been between 53% and 58% in the last three years. Two facts are of interest when analyzing those failure rates. First, students required to take Advanced Programming are Computer Engineering and Computer Science students who are supposed to have a better aptitude for computers in general. Second, Computer Engineering students have the second highest entrance index in average of all the engineering students (333 minimum entrance index, out of 400) and the Computer Science students have the highest entrance index in average of all students except for engineering programs (305 minimum entrance index, out of 400). One may ask, why are those failure rates so high? The authors concluded that the reason for those high failure rates is that basic skills and techniques needed to develop computer programs and solutions involving computers are not fully developed when they take Algorithms and Computer Programming. This is due to a lack of new methodology implementation and high-tech facilities in the classroom that could help the instructors in teaching.

Table 1

Gatekeeper Course Data	#	%
Students on average per term who enrolled in the course (average of last 3 years)	539	na
Engineering and computer science majors who took the course during the 2000-2001 school year	361	na
Students on average per term who received a grade of B – or better (based on an average of last 3 years) and % of these students compared to course enrollment	228	42.3
*na = not applicable	na	na

ASPECTS OF THE GATEKEEPER COURSE THAT WILL BE ADDRESSED IN THE REDESIGN

The key elements of the proposed reform are: emphasis on student-centered learning, where lectures are minimized and substituted with active inquiry activities, interactive demonstrations and cooperative learning, complemented by

accessibility of the course material on the Internet. Classes must also provide activities to engage all type of students and allow time for them to self-assess and reflect on their own learning.

The redesigned course will be a one and a half hour class that includes a combination of short periods of lectures and class discussion (10 to 15 minutes) followed by tasks that engage students in active learning. During the short lecture the instructor will give the theoretical background and fundamentals of each topic. The instructor will also show examples of programming segments applying the material covered. Everything will be projected over the classroom screen and also will be available in the course's Internet page. Parts of some lectures will be taped both for the purpose of class review and faculty workshops. The students will practice the concepts applying the knowledge just acquired in an array of diverse methods that will be discussed in due course.

In order to provide a teaching environment that promotes that kind of preparation in our students, the traditional teaching methods have to evolve. The cooperative learning in active student–centered activities approach have proven to be effective to reach "at risk students" as well as to improve academic performance [12] and promote adequate interpersonal skills that prepare them to work effectively in their future job [13] . These methods actively engage students in the learning process, promote depth of understanding and the development of higher order cognitive skills. Their discussion or collaborative work will be graded equally for everybody in the groups.

Lectures simply reinforce students' feelings that the most important step in mastering the material is memorizing a zoo of apparently unrelated examples. In order to address these misconceptions about learning, we propose to use Peer Instruction, which involves students in their own learning during lecture and focuses their attention on underlying concepts. Lectures are interspersed with conceptual questions, called Concep Tests, a method developed by Eric Mazur [14] from Harvard University, designed to expose common difficulties in understanding the material. The students are given one to two minutes to think about the question and formulate their own answers; they then spend two to three minutes discussing their answers in groups of three to four, attempting to reach consensus on the correct answer. This process forces the students to think through the arguments being developed, and enables them (as well as the instructor) to assess their understanding of the concepts even before they leave the classroom. This process could be optimized by the availability of the Wireless technology and software that enable them to cooperate as the instructor oversee the whole process.

The student will be assigned exercises during the hands-on part of the class that they will solve in their Notebook computers. The instructor will grade students' exercises as they come available to his/her Notebook from each student through the use of a specialized software. Advanced students may leave the room once they have finished their exercises or may stay practicing older topics, completing programming projects or making plans within their cooperative learning group. Students having problems with the assigned exercises will then have the "consulting services" of an instructor or a teaching assistant during the class period. The Instructor uses the specialized software to immediately asses the student's performance. This will add flexibility and a new dimension to the Algorithms and Computer Programming class. The teacher will help each student individually. Using diverse assessment techniques like those presented in Classroom Assessment Techniques and in the Field Tested Assessment Guide [15]. With the specialized software as the tool, professors use authentic assessment by gathering, organizing and interpreting information that facilitates reflection on their students' learning process and allows them to make judgments on their performance.

EVALUATION ON RETENTION, NUMBER OF STUDENTS SERVED AND INSTRUCTOR WORKSHOPS

The gatekeeper course passing rates will be compared between the pilot (redesigned) and the current traditionally taught sections. An information database of the students who took the course will be developed to follow them up over 36 months. Interviews will take place at regular intervals with students, including those who drop the course. The questions will gauge both proficiency, and attitudes and perception about the teaching methodology.

Approximately 150 students will be enrolled in the redesigned course. This represents six sections during the first semester. It is expected that at least, three additional sections will be served during the second semester of the project. During the first semester there will be two professors using Mobile Classroom with 3 sections of the Algorithms and Computer Programming course each (a total of 6 sections). During the spring semester there will be three additional professors with at least a section each. Two workshops will take place each semester for professors interested in using the Wireless Classroom and the specialized software along with effective teaching tecniques to redesign their courses. The workshops will include theory of equipment, software and teaching methods used, video of classes taught and recorded using the digital camera included with the equipment, and hands-on exercises. The Wireless Classroom workshop will become a regular offering of the UPRM Center for Professional Enrichment (CEP) with the additional advantage that the professors will be given credit for their participation.

CONCLUSIONS

Algorithms and Computer Progremming has been identified as a gatekeeper course for Computer Engineering and Computer Science majors. A redesign process is under development for the course Algorithms and Computer Progremming. By using technology and modern educational strategies an increase in retention of students in the areas of Computer Engineering and Computer Science is expected.

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