Retention 101: Where Robots Go … Students Follow

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Abstract

At Indiana University - Purdue University Fort Wayne (IPFW) we have developed ETCS 101 - Introduction to Engineering, Technology, and Computer Science, a freshman success course for students in the School of Engineering, Technology, and Computer Science (ETCS). The main objective of this course is to help students find a successful career path early in their studies, i.e. increase retention. The course aims to provide students with sufficient computer and personal development skills and to help them develop the right mental attitude conducive for academic success. Features of the course include projects of software and hardware nature, extensive use of the Internet and Web software tools, and a team-teaching format. As the main project of this course, small teams of students design, build, program, and test an autonomous mobile robot using LEGO® parts, sensors, and the Robotic Command eXplorer (RCX) controller. This is a multidisciplinary, project-driven learning process that encourages students to develop problem solving and teamwork skills and fosters their creativity and logic. Robotic projects are multidisciplinary in the sense that they involve a wide range of disciplines; including computer science, physics, math, biology, psychology, engineering, and art.

Introduction

Indiana University – Purdue University Fort Wayne (IPFW) is located in the second largest city in Indiana and it is the sixth largest public university in the state. Total enrollment is approximately 10,000 students. IPFW is a commuter university (there is no on-campus student housing) and many of the students attend classes on a part-time basis. The average student age is 27 years. The School of Engineering, Technology, and Computer Science (ETCS) enrolls approximately 1400 students and is comprised of five departments: Civil & Architectural Engineering Technology, Computer Science, Electrical & Computer Engineering Technology, Engineering, and Manufacturing Technology. Certificate, associate, bachelor, and master degree programs are offered and awarded by Purdue University. ETCS students are a mix of traditional and non-traditional age students. Many of the students who apply for the first time to any of the departments of the School of ETCS are adults who have been out of school for several years. These non-traditional students usually hold part-time or full-time jobs in local industry and are highly motivated in earning a degree in a technical field, but their knowledge about the disciplines of engineering, technology, and computer science is limited. This lack of knowledge about engineering is also common in the traditional

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freshman engineering students [1]. A large percentage of both traditional and non-traditional students lack the proper mindset and computer skills for success in both academic and career work in a technical field. Computer skills and the right attitude towards obtaining a technical degree have been strongly correlated with retention [2, 3].

While it is true that a number of students who enter a particular program do not belong there, most are highly motivated towards earning a degree in a technical field. The majority of the students who find difficulties with their initial degree choice leave IPFW altogether while only a small percentage explore other programs within the School of ETCS or pursue different majors available in other schools on campus. To address this situation, we have developed and implemented a high-tech freshman success course, ETCS 101 - Introduction to Engineering, Technology, and Computer Science that helps students acquire sufficient computer and personal development skills for a successful college career. The course provides students with an introduction to several technical disciplines, timely academic counseling, and career information. Features of the course include multidisciplinary projects of software and hardware nature, extensive use of Web software tools, and a team-teaching format. Similar motivating features have been used in freshman engineering courses developed elsewhere [4, 5].

Numerous studies [6, 7] have found a positive correlation between sophomore return rates and participation in a freshman success course. This is particularly true in a technical degree program[8]. Cheshier [9] reports that less than 50 percent of students entering engineering and engineering technology programs earn their degree in that field.

As shown in Table 1, our retention rates are lower than those described in these studies. Table 1 also shows that only a small percentage of students explore other programs within the School of ETCS or in other schools at IPFW. We believe that this trend is due to the nature of our student population and our university.

Table 1

1999 Status of ETCS Students First Enrolled in Fall 1995

	Number		**Percentage**	
First enrolled in 1995	283			
Retained in ETCS	53		20.14	
Remained in the same ETCS Department		36		12.72
Graduated		14		4.95
Received Certificates		1		0.35
Changed ETCS department		6		2.12
Left ETCS but remained at IPFW	43		15.19	
Left IPFW	183		64.66	

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The Students

To gain an insight in the background of the students and to validate the premises under which the course is being developed, a survey is conducted at the start of the semester. Students are asked about their:

- choice of major,
- mathematical background,
- computer expertise,
- number of hours per week dedicated to work,
- number of hours per week dedicated to study,
- number of credits being taken,
- oral and written communication skills,
- ability to work with others,
- knowledge of professional ethical standards and world affairs.

The results of this survey as well as the course evaluations conducted at the end of the semester are used to assess and update the course content. Since a major claim of the course is its high-tech nature it is important to continuously revise the nature and content of the projects to address the perceived shortcomings in the backgrounds of the students. Figure 1 shows the computer skills of the students surveyed at the start of the fall 2001 semester (111 students filled the on-line survey).

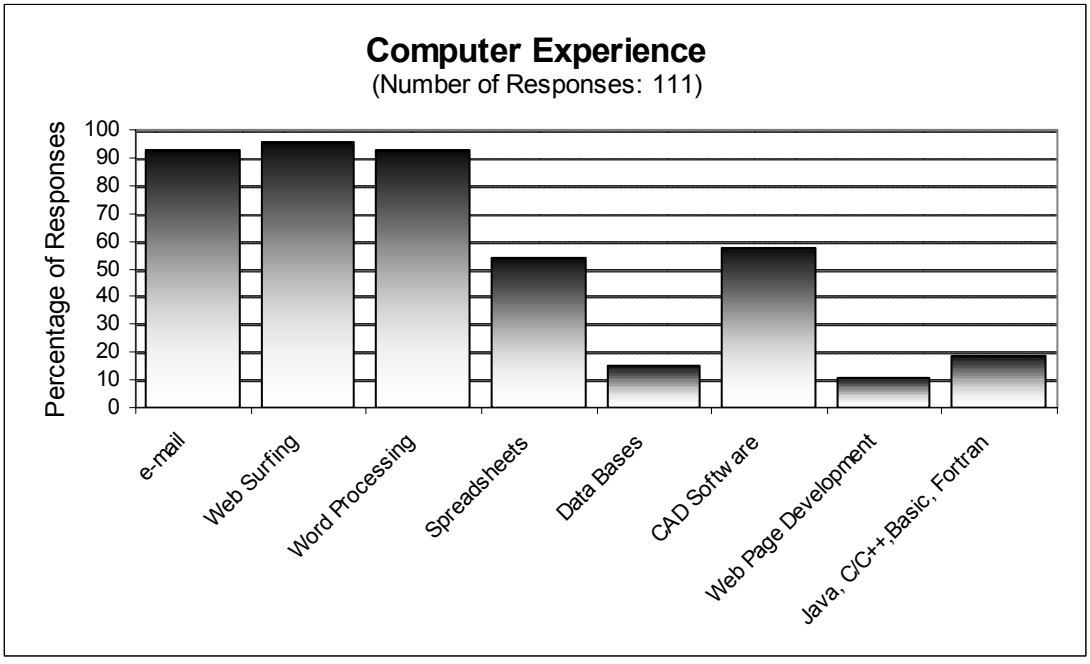

Figure 1. Survey results. Fall 2001

It is apparent from Figure 1 that the areas where the students have the least background are in programming languages and in Web page development. On the other hand, most students are very

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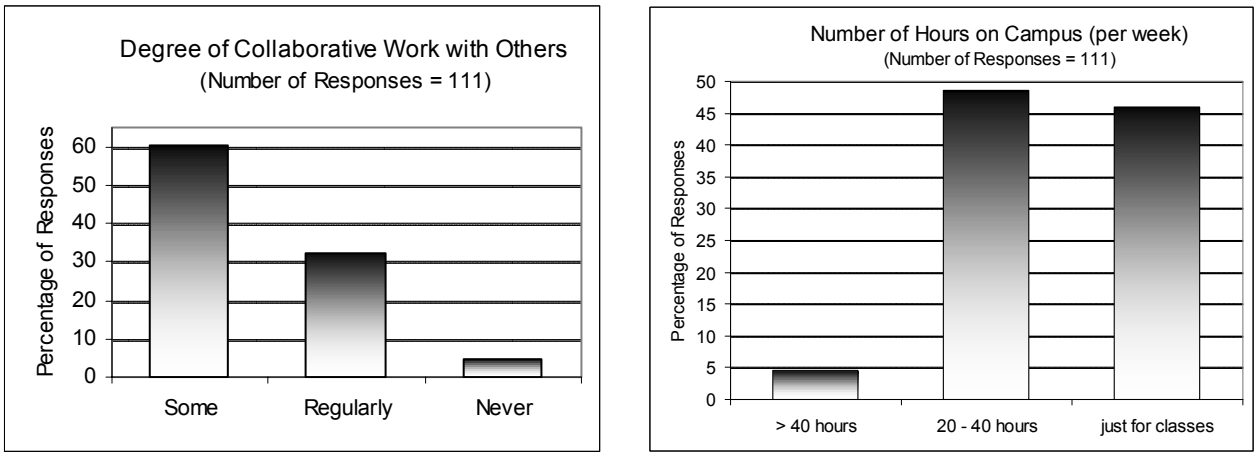
proficient in the use of e-mail, word processing tools, and Web surfing. Figure 2 (a) summarizes the answers to the question of the frequency of collaborative work with others and Figure 2 (b) illustrates the amount of time that students spend on campus.



(a) (b)

Figure 2. Survey Results. Fall 2001

These survey results have been consistent for the last two years and give strong support for the need of a course such as ETCS 101. Our students need to increase their computer and programming skills in a positive environment, and they have to be given the chance and means to interact more with each other.

The Autonomous Mobile Robot

The main project in ETCS 101 is the mobile robot. Small teams of students design, build, program, and test a mobile Robot using LEGO parts, sensors, and the RCX controller. This is a multidisciplinary, project-driven learning process. It helps students to develop problem solving and teamwork skills and foster their creativity and logic. By working on this project students are introduced to:

- making iterative improvements
- working with systems
- working in teams
- modularity and abstraction
- feedback and control
- attention to aesthetics
- the value of simplicity and robustness

All students are involved in building and programming the robot. In addition, each student is assigned a specific role on the team. These roles, shown in Table 2, are decided at the beginning of the project through meetings and discussions among the team members. In forming the teams an effort is made to combine experienced and novice students into a single team of three or four

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members. The quality of their personal web site (first course project) is used to gauge the students' computer expertise. This robot project has similar objectives to the one described by Avanzato [10] but the scope here is on a smaller and simpler experience. Also the inclusion of this exciting technology creates a motivational atmosphere at the gateway of the curricula [11].

Table 2

Member Roles

Team Member	Role
Manager	• Oversees the team's activities • When issues arise, negotiates a consensus among the team members on how to proceed • Ensures that the project is moving forward on schedule
Material Specialist	• Tracks the use of the hardware, software, building elements and other materials • Distributes materials • Keeps an inventory and makes sure everyone stores the materials properly
Webmaster	• Designs and builds the team's web site • Records the week's work in the on-line team journal
Information Specialist	• Collects and summarizes the information for the project, making sure that this information (papers, books, web pages, etc.) is in order and the team members know where they can find it

Building sets from the LEGO Challenger System are used for this project. This project allows each team to develop their own design within a range of specifications. These specifications include a maximum number of components, such as light sensors, gear motors, and resource bricks and one RCX controller (Figure 3). In the first phase of the project, the teams design and build their robots. In the second phase, the teams program the robots to perform the required tasks. ROBOLAB, an icon-based software tool, is used to write the programs that are then downloaded to the robot controller via an infrared link. The third phase of this project is a demonstration of each team's robot. On the demonstration day, the teams show how their robots perform their assignments in the Engineering and Technology Building's main lobby. In this way, not only students taking the course, but also other students, faculty, and staff have the opportunity to appreciate the projects. Teams are also required to write a project journal and a final report (on a web page) that describes the planning, design, building, programming, testing, and demonstration of the robot. They are asked to include pictures and diagrams of their robots and programs.

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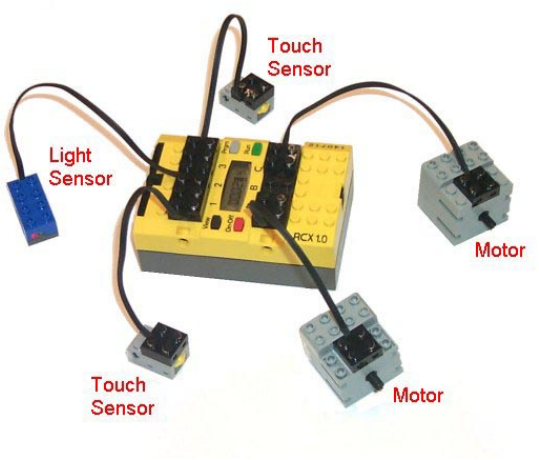

Figure 3. The RCX controller, motors, and sensors

Assessment of Course Objectives

Whereas the scope and depth of robotics in ETCS 101 is less than a formal one-semester robotics course, its inclusion in this freshman success course aimed at engineering and technology students has been very positive. Student assessments at the end of the semester consistently report that what they have enjoyed most in the course is the mobile robot project and through it, how to work as a team. Figure 4 shows the responses to the open ended question, "What did you like most about this course?"

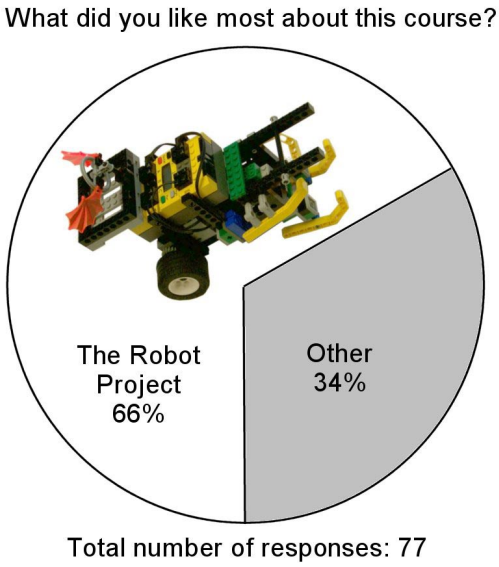

Figure 4. Fall 2001. Response to a course assessment question

These results are similar to the ones reported by Goff [12], where the importance of a hands-on laboratory with interesting, challenging and fun activities has been highlighted as a way to introduce

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students to a technical field in a freshman course. The experience of bringing a design from concept to working prototype is valuable preparation for subsequent education and employment [13, 14].

ETCS 101 was first offered as a pilot course in the fall 1999 and in the spring 2000 semesters. A Lilly Foundation grant allowed for the full financing of the course expenses during the 2000-2001 academic year. In the fall of 1999, only students from the Department of Engineering took the pilot course. The course was offered as one of two sections of ENGR 100-Introduction to Engineering. The other section of ENGR 100 followed the old format of that course which primarily consists of a series of seminars about the engineering profession. Tables 3 and 4 below illustrate the current status of students enrolled in the two sections.

Table 3

Fall 2001 Status of engineering students enrolled in ENGR 100-01
(old ENGR 100 format)

	Number		Percentage	
First enrolled in the Fall of 1999	35			
Retained in ETCS	22		62.86	
Remained in the same ETCS program		15		42.86
Graduated		2		5.71
Received certificates		0		0
Changed ETCS program		5		14.29
Left ETCS but remained at IPFW	6		17.14	
Left IPFW	7		20.00	

Table 4

Fall 2001 Status of engineering students enrolled in ENGR 100-02
(Pilot course of ETCS 101)

	Number		Percentage	
First enrolled in the Fall of 1999	30			
Retained in ETCS	24		80.00	
Remained in the same ETCS program		15		50.00
Graduated		0		0
Received certificates		0		0
Changed ETCS program		9		30.00
Left ETCS but remained at IPFW	1		3.33	
Left IPFW	5		16.67	

Tables 3 and 4 provide evidence that the new course, ETCS 101, has a very positive impact on retention in the School of ETCS. In this comparison both the control and the test groups were made up only of students enrolled in the engineering program.

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Tables 4 and 5 show the current status of students enrolled in ETCS 101 during the fall 2000 and spring 2001 semesters. During that academic year, students from the Department of Engineering as well as from two technology departments, Civil and Architecture Engineering Technology (CAET) and Manufacturing Technology (MFT) enrolled in ETCS 101. The total enrollment also included a handful of students from the Computer Science (CS) and from the Electrical and Computer Engineering Technology (ECET) departments. ETCS 101 is now a required course in the curriculum of the engineering, CAET, and MFT programs while students in the CS and ECET departments take it as an elective.

Table 5

Fall 2001 Status of engineering students enrolled in Spring 2001

	Number		Percentage	
First enrolled in the Spring of 2001	49			
Retained in ETCS	47		95.92	
Remained in the same ETCS program		41		83.67
Graduated		0		0
Received certificates		0		0
Changed ETCS program		6		12.25
Left ETCS but remained at IPFW	2		4.08	
Left IPFW	0		0	

Table 6

Fall 2001 Status of engineering and technology students enrolled in Fall 2000

	Number		Percentage	
First enrolled in the Fall of 2000	85			
Retained in ETCS	80		94.12	
Remained in the same ETCS program		74		87.06
Graduated		0		0
Received certificates		0		0
Changed ETCS program		6		4.70
Left ETCS but remained at IPFW	5		5.88	
Left IPFW	0		0	

The results shown in Tables 4 and 5 cover only a one year period and thus are preliminary, but they point to a very positive retention outcome. We plan to follow up the status of the students in the next years to better assess the impact on retention.

Conclusions

The importance of a successful introductory course to the engineering, technology, and computer science disciplines has been highlighted. The main objective of this course is to help students find a successful career path early in their studies. The course provides students with an introduction to several technical disciplines, timely academic counseling, and career information. A very important

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component of the course are the projects that are student-centered and of a multidisciplinary, high-tech nature. As a result of these projects the students achieve a basic competence in the use of computers and working in a team. More information about this course can be obtained at http://raven.ipfw.edu:8902, sign in as "guest" and also use "guest" as the password.

At IPFW, we have extended the application of LEGO Robotics. The program includes robotics camps for children, a workshop for teachers, robotic tournaments (Figure 5), and career day presentations. Former and current ETCS 101 students actively participate in these activities that are designed to motivate and foster the interest of our youth in science and technology. We have chosen the LEGO sets to introduce the concepts of robotics to people of all ages and backgrounds because these sets are relatively inexpensive, durable, and a familiar tool. Another advantage of this program is that the projects are scalable in complexity and as such they can be used throughout the K-16 curricula. Robotics combines electrical, mechanical, and computer science technologies, it is an applied field and its applications affect everyday life. For more information about our LEGO robotics program visit http://raven.ipfw.edu

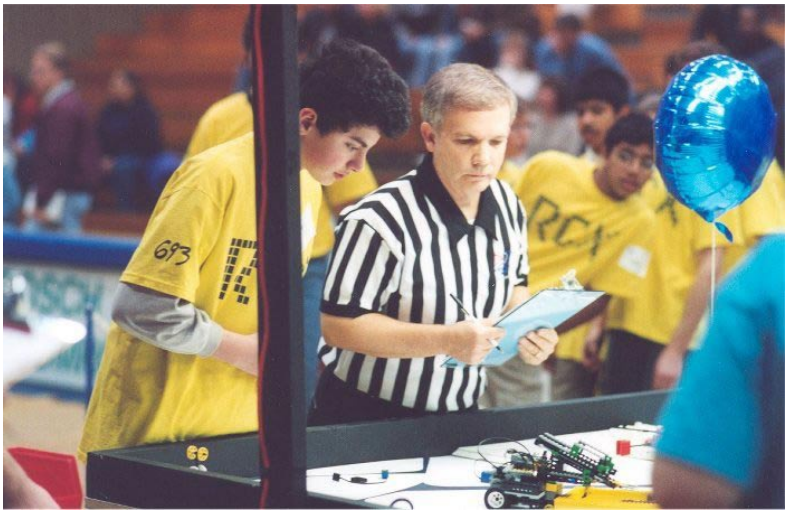

Figure 5. FIRST Lego League 2001 Tournament. The Arctic Impact Challenge.

References

1. Mullins, Carie A., Atman, Cynthia J., Shuman, Larry J., and Gotfried, Byron S., "Freshman Expectations of an Engineering Program," *Proceedings of the 1995 ASEE Annual Conference*, June 25 – 28, 1995, Anaheim, California, vol. 1, pp. 173-178.
2. Davis, G. J., "An Introduction to Computer Programming for Students with No Programming Experience," *1991 Frontiers in Education Conference Proceedings*, September 21-24, 1991, West Lafayette, Indiana, pp. 748-752.
3. Besterfield-Sacre, M., Atman, C.J., and Shuman, L. J., "Characteristics of Freshman Engineering Students: Models for Determining Student Attrition in Engineering," *Journal of Engineering Education*, vol. 86, no. 2, April 1997, pp. 139-149.

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4. Mandayam, S., and Udpa, Satish S., "Motivating Engineering Freshmen with Buzz-Words: High-Tech Applications in Introductory Engineering Courses," *Proceedings of the 1997 27th Annual Conference on Frontiers in Education*, November 5-8, 1997, Pittsburgh, PA, vol. 3, pp. 1206-1211.
5. Piket-May, Melinda J., and Avery, James P., "Results of Client Based Freshman Design Projects," *Proceedings of the 1997 27th Annual Conference on Frontiers in Education*, November 5-8, 1997, Pittsburgh, PA, vol. 3, pp. 634-637.
6. Barefoot, Betsy O., Exploring the Evidence: Reporting Outcomes of Freshman Seminars, The Freshman Year Experience: Monograph Series Number 11, South Carolina University, Columbia, South Carolina, 1993.
7. Hodum, Robert L., Martin, Oneida L., "An Examination of College Retention Rates with A University 101 Program," Proceedings of the Annual Meeting of Mid-South Education Research Association, November 11, 1994, Nashville, Tennessee.
8. Johnson, Keith V., "The Freshman Experience: Improving Retention in Engineering Technology," *Proceedings of the 1995 ASEE Annual Conferenc*e, June 25 – 28, 1995, Anaheim, California, vol. 1, pp. 518-525.
9. Cheshier, Stephen R., "Needed: Student Success Courses for Beginning Engineering Technology Students," Proceedings of the 1999 ASEE Annual Conference, June 20 – 23, 1999, Charlotte, North Carolina.
10. Avanzato, R., "Collaborative Mobile Robot Design in an Introductory Programming Course for Engineers," *Proceedings of the 1998 ASEE Annual Conference*, June 28 – July 1, Seattle, Washington.
11. Genalo, L. J., Williams, B. D., "The Freshman Engineering Problems and Programming Course: Integrating New and Old Tools," *Proceedings of the 1995 ASEE Annual Conference*, June 25-28 1995, Anaheim, California, pp. 1532-1536.
12. Goff, R.M., Gregg, M.H., "Freshman Hands-On Engineering Laboratory at Virginia Tech," The *Innovator*, The SUCCEED Newsletter, no. 11, Spring 1999, pp. 12-15.
13. Starr, G.P., "The UNM Mechanical Engineering Lego Robot Competition," *Proceedings of the ASCE Specialty Conference on Robotics for Challenging Environments*, 1998, pp. 230-236.
14. Hayes, G.M., and Hallan, J.C.T., "Teaching Robotics with Lego Robots," *IEEE Colloquium (Digest)*, 1995.

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