Educating for Success in Engineering: Re-shaping the First-Year Experience

***Taunya A. Phillips*[1]**

Abstract

A love of math and science is why many students choose engineering as a major. However, most students have only a partial knowledge of what engineers actually do, and most students are not aware of the multitude of career possibilities that can be realized with an engineering degree. Generally, few engineering courses are taken in the first two years of the curriculum. Moving the engineering experience to the first semester of the freshman year gives students the information they need to make career decisions.

Introduction

The first step in "Educating for Success" in engineering is to provide students with the information and skills they need to be successful. At the University of Kentucky College of Engineering, this is accomplished through the first year course, EGR 101: Introduction to Engineering. No longer does the mindset exist that students enter engineering with the necessary skills to be successful (swim) or else they do not belong (sink). By giving freshmen an introduction to engineering basics, along with "soft skills" demanded by ABET EC 2000, EGR 101 aims to give students the information they need to make an informed decision about whether or not engineering is the right career choice for them.

Since its debut as an experimental course in 1998, EGR 101 has evolved into a concise and effective avenue for introducing students to the world of engineering. In its original format, EGR 101 was a two-semester sequence, 4-credit hour course that followed Drexel University's model. In 1999, it was condensed to one semester, but remained a 4-credit hour course. The major change occurred in the measurement (physical) laboratories. Instead of doing 21 measurement labs, largely based on electrical engineering concepts, there are 6 measurement labs whose concepts can be applied across several engineering disciplines.

Refinement occurs after each year EGR 101 is taught. Eight very active faculty members, the EGR 101 Team, meet several times a year to assess and improve the course. All have contact with the students either as a lecturer or as a lab instructor. Additionally, as many as fifteen other people from various departments and functional areas across campus participate in some way. Currently, there are three teaching assistants to support six sections.

Originally, EGR 101 was totally voluntary. Students used it as a substitute for the discipline-specific engineering professions class, and it satisfied a university requirement. Although the hope

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[1] University of Kentucky, 381 Ralph G. Anderson Building, Lexington, KY 40506-0503, tphillips@engr.uky.edu

was to make EGR 101 mandatory across all disciplines, Mechanical Engineering is the only department that adopted it fully. This has several implications for the future direction of the course and the retention of students.

Course Objectives

One of the primary objectives of EGR 101 is retention and redirection. Many students decide on engineering as a major not knowing all that it entails. The course is designed to provide students with enough information to make the decision to stay in engineering or pursue another career path. Being able to make this decision after the first year in college is a major advantage to students that choose to leave, as well as those that choose to stay.

EGR 101 also aims to provide students with an overview of the engineering profession. Each engineering department sends a representative to talk to the students about its curriculum, sub-disciplines and potential career paths. Further, the students are required to visit at least one department in which they are interested.

Basic engineering skills are also learned in EGR 101. Design projects, measurement labs, computer-based labs, and communication exercises are the primary avenues for developing the engineering skill set of the students. Assignments introduce the students to the problem-solving issues related to engineering design. The measurement lab offers an opportunity to learn the fundamentals of instrumentation and laboratory experimentation. The virtual computer labs enhance the students' ability to use software applications for the analysis and presentation of engineering data.

Indications from private industry, as well as mandatory requirements from ABET, necessitated the inclusion of team-based experiences in the EGR 101 course. The objective is to form a team-based mindset in first-year students. Thus, they will understand the expectation to be an effective team member in future engineering courses and in the workplace.

EGR 101 strives to provide a "safe haven" from large, non-interactive math, science, and general studies courses. Enrollment is capped at 26 so that students feel comfortable in their environment, camaraderie materializes, and students can develop relationships with the many lecturers for the course. Moreover, EGR 101 allows them to experience an environment where fellow students have common goals and interests.

Lastly, the College of Engineering wants to attract bright young minds from the Commonwealth of Kentucky and surrounding areas, so EGR 101 is often touted to potential students during recruiting. The opportunity to find out what engineering is all about and to gain some basic skills before taking more difficult engineering courses is desirable.

Course Structure

EGR 101 is structured such that the students attend a 50-minute lecture three times a week, and they alternate between a 3-hour measurement lab and a virtual computer lab assignment each week. Lectures are the primary component of the course. The following list exemplifies the variety of topics covered and some associated activities that are designed to reinforce the importance of the topic to engineering.

- **Engineering Design** comprises eight lecture classes. One lecture, titled *Design Philosophy*, focuses on the engineering design process. On the first day of class, students are divided into five teams and given an "impromptu" design assignment. Each team

works outside of class to get their design ready for competition five days later. At midterm, teams submit competition ideas that employ Lego MindStorms™, and are then voted on by the class for the final design project.

- **Team Building** experience is achieved through the design project work. In addition, the students are taught basic tools for being an effective member of a team, as well as how to operate as an effective team. The goal is to provide a good understanding of group development, task allocation, group conflict, and leadership.

- **Written and Oral Communication** are covered through lectures and through written and oral design reports. The importance of effective written and oral communication skills are emphasized. Thus, the students have several opportunities to speak in front of the class and write technical reports.

- **History of Engineering** discusses engineering from a historical perspective. Lectures are based on the popular book Connections by James Burke.

- **Discipline Overviews** are provided by representatives from each of the seven undergraduate disciplines at the University of Kentucky. Each discipline also gives a tour of its facilities. Participating engineering departments include: Biosystems/Agricultural, Chemical and Materials, Civil, Electrical and Computer, Mechanical, and Mining. These overviews provide an increased appreciation and understanding of the engineering profession and the interaction between engineering disciplines.

- **Ethics** lectures are designed to highlight the importance of ethics and professional responsibility in engineering. They emphasize the impact engineers have on public health and safety, and show how business practices and politics can influence the work of engineers. Students are engaged in the lectures through case studies.

- **Study Skills** provides strategies for success in math, science and engineering courses, as well as for time management. A representative from the Counseling and Testing Center incorporates upper-class engineering students in his lecture in order to bring reality to the discussion.

- **Information Skills** provides students with the basics of doing engineering research using the Internet within the UK library system. The engineering librarian shows the students which databases are best for doing patent searches, and technical research.

- **Career Preparation** is covered through several presentations. The Cooperative Education director discusses resume writing and employment. Additionally, one lecture is devoted to discussing the various paths one can take with an engineering degree.

- **Diversity** is designed to bring awareness to diversity issues and to explore the impact of prejudicial attitudes and behaviors in engineering team-based environments.

- **Engineering Student Organizations** send their leaders to the EGR 101 classes to talk about the benefits of being a part of their organizations and highlight some of the project teams that might interest students.

- **Entrepreneurship** reveals the link between engineering/technology, business, and law. The president of the campus e-Club illustrates these connections through an interactive exercise.

- **Guest Speakers** from industry talk about their various experiences in engineering and business. Representatives from Cummins Engines, IBM, and General Electric have participated. Since Dr. Lee Todd became president of the University of Kentucky in 2001, he has spoken to the EGR101 classes each year about his experience as an electrical engineering student and professor, and as an entrepreneur.

The measurement laboratory is designed to introduce students to the fundamental concepts of working in a laboratory setting and to show how physics and calculus relate to engineering. In this setting, students acquire basic engineering measurement techniques, become familiar with instrumentation, and learn to properly obtain and analyze data. Each lab covers a physical topic and has an associated mathematical theme in order to facilitate an appreciation and understanding of why math, physics and chemistry are important to engineering. The measurement labs are:

- Introduction to Engineering Measurement Techniques
- Linear Dimensional Measurements
- Mass Measurements
- Time-Varying Signals
- Heat and Temperature Measurements
- Periodic Motion

The virtual computer lab (VCL) is virtual in that students get their assignments from the course web site and complete it outside of the formal computer lab setting. They are designed to give a solid foundation in using computers as an engineering tool for communication and problem solving. Assignments involve students setting up their engineering email account, spreadsheets, and numerical computing using MATLAB®. The VCL labs are:

- Introduction to Campus Computing
- Spreadsheets I – Graphing Data
- Spreadsheets II – Simple Statistics
- Spreadsheets III – Curve Fitting
- Numerical Computing I - Graphing
- Numerical Computing II - Programming
- Numerical Computing III – Simulations and Animation

Results

Retention statistics since EGR 101 began in 1998 (Figure 1) show that one of the primary objectives of the course, retention and redirection, is being met. Retention of EGR 101 students in the University has increased every year since the course's inception, and it has remained above the figures for non-EGR 101 students. Thus, the course is effectively redirecting to other majors those students that are not interested or not prepared to pursue engineering, keeping them at the University. In like manner, EGR 101 students are retained in engineering at higher rates than non-EGR 101 students.

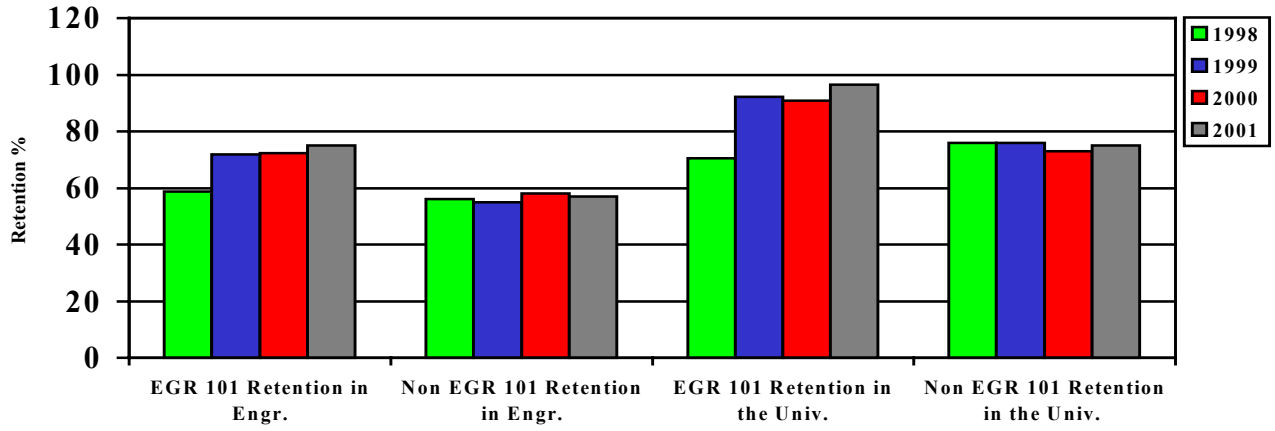

Figure 1. Retention Statistics – Students that took EGR 101 versus those that did not.

For some students the decision is engineering or not, for others it is which engineering field. A majority of the EGR 101 students have strong backgrounds in math and science, but they are not totally sure how they want to use their talents. Apparently, the department overviews and visits give the students a good sense of how their interests align with the various fields of engineering. Many said that this part of the course helped them to make their decision about which, if any, engineering discipline they should choose.

Feedback from students indicates that the design projects helped them to learn the design process itself and learn to consider things like functionality, cost, and efficiency in their designs. Doing the design projects in a competition format allowed the students to immediately see how well they did in meeting the objectives of the project. Further they were able to assess the effectiveness of their team.

EGR 101 students do not immediately recognize the significance of the measurement labs and the virtual computer labs; they find some of them tedious. However, once they are a year or two removed from the course, the value of the labs becomes apparent. Students comment that knowing how to use spreadsheets to organize and manipulate data helps with other laboratory courses where large amounts of data must be analyzed. Knowledge of MATLAB® is an asset in junior and senior level courses that require numerical modeling.

Students remark that the EGR 101 class environment is a refreshing change from that of more structured courses such as calculus and chemistry. The atmosphere is conducive to the development

of friendships, and more importantly, study groups. They feel at ease in a place where their classmates can relate to their struggles as a first year engineering student.

Issues

EGR 101 has succeeded at meeting the objectives of the course, yet there are still issues that could jeopardize its future. As stated earlier, only one department, mechanical engineering, has made EGR 101 a curriculum requirement. If the other departments do not follow suit, the course will likely lose the cross-disciplinary faculty support and diversity in student majors that it has enjoyed (Figure 2). Departments have been slow to adopt EGR 101 for various reasons. Some pertain to concern over adding a net of three hours to their curriculum. Others have to do with the perceived value to the department. Based on student participation and comments, the core faculty for EGR 101 believes that the course is very beneficial and plans to "sell" it to the departments using the retention data.

EGR 101 Freshmen	**1998**	**1999**	**2000**	**2001**	**2002**
Mean ACT/M Score	29.8	30.4	28.8	28.9	28.6
Standard Deviation	2.8	2.6	2.6	3.7	3.9
Range	12	10	12	17	18
NON EGR 101 Freshmen					
Mean ACT/M Score	27.0	26.5	26.4	26.3	26.3
Standard Deviation	4.2	4.4	4.3	4.4	4.2
Range	21	21	21	24	21
Upperclassmen	1	3	5	6	40
Non Engineering Majors	0	2	1	3	6
Biosystems/Ag. Engr.	1	5	2	4	1
Chemical Engineering	6	6	9	10	5
Civil Engineering	6	6	11	26	6
Computer Science	0	0	7	3	6
Electrical Engineering	3	9	10	12	14
Materials Engineering	0	1	4	4	3
Mechanical Engineering	15	12	23	25	104
Mining Engineering	1	0	0	1	11
Total	32	41	67	88	156

Figure 2. EGR 101 class profiles.

Because mechanical engineering made EGR 101 mandatory starting in 2002, the number of upperclassmen that take it has dramatically increased (Figure 2), with most transferring from other institutions. Thus the dynamics of the class and particularly the team-based activities are affected. A special section for upperclassmen is being considered in order to protect the true intent of the course.

The other issue with mandatory versus self-selection has to do with the caliber of student taking EGR 101 and how that relates to retention. With self-selection, a limited number of sections, and the best students registering first, the average ACT math score of EGR 101 students is, on average, almost three points higher than those not taking it (Figure 2). Some would say that these students naturally have a better chance of being retained. Hence data collected in September 2003 will give a better picture of how EGR 101 impacts retention.

With enrollment in EGR 101 increasing each year, resources are becoming an issue. Additional faculty is needed to teach, measurement lab space is limited. In addition, the dean of the College of Engineering is currently supporting the cost of materials that must be purchased each semester. However, the resource issue could easily be resolved on all fronts when EGR 101 is required for all engineering majors.

Conclusions

The benefits of EGR 101 are in alignment with ABET EC 2000 outcomes. After completing the course, students are receiving an increased appreciation and understanding of the engineering profession and the interaction between engineering disciplines. They understand why math, physics and chemistry are important to engineering. They have hands-on experience with design, computer problem solving, instrumentation and lab experimentation. The students appreciate the value of communication skills to engineering and have had several opportunities to practice them. Lastly, they have actively participated on a design team. All of this in an atmosphere of collegiality!

The fact that the EGR 101 students generally have higher math ACT scores is not the whole reason for better retention statistics than the Non-EGR 101 students because student leave engineering and the sciences for a variety of reasons. By making the course fun and exciting, yet challenging, the students are able to see themselves as engineers, thereby improving the chance of retaining them.

Upon resolution of the issues associated with EGR 101, the future direction could mean even higher retention rates of engineering students in both the university and the college.

References

"IDMS SIS Production," Office of the Registrar, University of Kentucky, Lexington, Kentucky.

"Criteria for Accrediting Engineering Programs," Engineering Accreditation Commission, http://www.abet.org/images/criteria/eac_criteria_b.pdf.

"EGR 101 Student Survey," Phillips, Taunya A., December 17, 1999.

"EGR 101 Student Survey," Phillips, Taunya A., December 13, 2000.

"EGR 101 Student Survey," Phillips, Taunya A., December 12, 2001.

"EGR 101 Student Survey," Phillips, Taunya A., December 20, 2002.

"EGR 101 Team Discussions," Crofcheck, Czarena, Jamey Jacob, Sue Nokes, Johne' Parker, Taunya Phillips,Scott Shearer, Joe Sottile, Bruce Walcott, 1999-2003.