Int. J. Engng Ed. Vol. 22, No. 6, pp. 1129–1138, 2006
Printed in Great Britain.
0949-149X/91 $3.00+0.00

Focus on Experiential Education: A Freshman Engineering Program in Biological Engineering*

W. TODD MONROE, MIKE MAILANDER and MARYBETH LIMA
Department of Biological & Agricultural Engineering, Louisiana State University, Baton Rouge, LA 70803, USA. E-mail: mlima1@lsu.edu

This paper describes a freshman engineering program implemented in the Biological Engineering curriculum at Louisiana State University. This program was initiated to address low student retention rates and was subsequently modified to address new evaluation criteria and a university focus on writing across the curriculum. Our model includes the drawing, design, and construction of hands-on, group projects, and requires frequent use of oral, written, and teaming skills. Results show that retention and graduation rates have improved, and that the program is considered successful by virtue of student assessment, exit interviews, and faculty reflections.

Keywords: engineering design, freshman, service-learning, experiential learning, retention.

INTRODUCTION

FRESHMAN ENGINEERING programs are becoming increasingly important in engineering education as educators realize the need for hands-on, applications-based experience to complement initial, rigorous, theory-based instruction in math, fundamental science, and engineering graphics. Schools began initiating freshman engineering programs in large numbers in the early to mid 1990s, and during this time, the National Science Foundation established funding programs targeted to address freshman engineering. One example is the Foundation Coalition, one of eight NSF-established teams of engineering institutions that serve as a resource for curricular reform at the foundation, or first two years, of engineering programs [1]. Programs such as these seek to improve engineering education by focusing on active learning strategies, participation of women and underrepresented minorities in engineering, student team projects, and technology-enabled learning [2]. These coalitions are now being supplemented with more discipline-specific centers such as the National Science Foundation-funded Vanderbilt-Northwestern-Texas-Harvard/MIT Engineering Research Center (VaNTH). VaNTH's vision is to transform bioengineering education to produce adaptive experts by developing, implementing, and assessing educational processes, materials and technologies that are readily accessible and widely disseminated [3]. These programs are mirrored in trends nationally, including curriculum overhaul to bring freshman design and resources 'up-front' in curricula [4]. Textbooks focused specifically on freshman engineering have proliferated in the past five years, with ten of the top twenty selling freshman texts having been published in 1999 or later [5].

A web search of freshman programs for biological, agricultural, and related engineering (BAE) departments in the USA, Canada, and Puerto Rico was conducted. Fifty-eight percent of these programs offer freshman courses within the discipline, 21% offer freshman courses in the college of engineering, and 21% offer no freshman courses. The BAE discipline is consistent with national trends in its offering of engineering courses specifically geared toward freshman engineering students. International universities with BAE listings were also polled, indicating different curricula structures. The majority of BAE departments from universities in Europe, Asia, Africa and South America include some form of curriculum-specific freshman course offerings. Retention rates at each of these departments were not queried, but prior studies that did analyze various engineering departments from programs abroad found graduation rates that varied from 15% to 98%, with a mean of 65% [6].

During the early 1990s, the Louisiana State University (LSU) BAE department initiated a curriculum overhaul in response to low student numbers in its traditional agricultural engineering curriculum. The department chose to eliminate the agricultural engineering curriculum, re-train existing faculty in biological engineering, hire newly trained faculty in this area, and fully implement a Biological Engineering (BE) curriculum in 1995 (see [7]). A freshman engineering sequence was added as part of this overhaul effort to address

* Accepted 11 August 2006.

low retention rates observed within the department by increasing student-department contact prior to the second semester sophomore class. Additionally the faculty instituted a series of 'core' competency expectations for students and designed a deliberate series of courses to accomplish this goal.

These courses, BE 1250: Introduction to Engineering Methods, and BE 1252: Biology in Engineering, were intended to provide information to help students understand and apply the concepts that they were learning in math, biology, physics, and chemistry. Additionally, the courses served to introduce students to peers and faculty immediately, strategies that the faculty felt was important to provide students with a professional identity and support system.

BE 1250 and 1252 were modified in 1998 (after three years of instruction) in response to two issues:

- the Accreditation Board of Engineering and Technology's Engineering Criteria 2000;
- a university-wide initiative for writing across the curriculum.

These changes involved the incorporation of hands-on, community-based activities to develop technical and communication skills. Details regarding these issues are contained in the paragraphs below.

The Accreditation Board of Engineering and Technology (ABET) is the organization responsible for monitoring, evaluating and certifying the quality of engineering (and related) education programs in the United States. Engineering Criteria (EC) 2000 is a set of standards with which engineering programs are evaluated; they represent a shift in evaluation strategies from content-based evaluation to outcomes-based evaluation. To meet accreditation standards, programs must demonstrate that students have mastered the basic tools of engineering practice and design and are able to effectively use them. Thus, engineering programs must show through rigorous assessment that their graduates can meet the 'a through k objectives' set forth by ABET EC 2000 Criterion 3 as follows:

a. an ability to apply knowledge of mathematics, science, and engineering
b. an ability to design and conduct experiments, as well as to analyze and interpret data
c. an ability to design a system, component, or process to meet desired needs
d. an ability to function on multi-disciplinary teams
e. an ability to identify, formulate, and solve engineering problems
f. an understanding of professional and ethical responsibility
g. an ability to communicate effectively
h. the broad education necessary to understand the impact of engineering solutions in a global and societal context
i. a recognition of the need for, and an ability to engage in life-long learning
j. a knowledge of contemporary issues
k. an ability to use the techniques, skills, and modern engineering tools necessary for modern engineering practice.

The BAE faculty responded to EC 2000 by examining the curriculum as a whole, adding specific exercises within the major courses to address these objectives, and determining appropriate assessment and evaluation strategies.

The writing across the curriculum (WAC) initiative was given priority at LSU to address persistent complaints from entry level employers across disciplines regarding the lack of sufficient writing skills displayed by university graduates. BAE faculty responded by adjusting the curriculum to provide ample opportunity for students to learn, practice, and master communication skills including written, oral, team, and leadership skills. The BE major designated several courses as writing intensive to meet university WAC requirements, which specified that one course during each year of the major must be writing intensive, and that at least three of these four courses be within the major of study. Details of this work are included in [8].

An ABET evaluator described the LSU BE curriculum as a model that other programs could emulate. The objective of this paper is to describe the freshman engineering program in biological engineering and to provide evidence to support the success of this program.

THE MODEL

The freshman engineering model we designed consists of two consecutive courses, BE 1250: Introduction to Engineering Methods, and BE 1252: Biology in Engineering. Though BE 1250 was intended to be the first course in the sequence, it is possible to take the courses in reverse order or concurrently. This flexibility is important to accommodate the diverse needs of students, many of whom are transfers. The courses typically consist of approximately 50% true freshmen; the remainder of the students are sophomores or juniors, the majority of whom have transferred from majors such as biological science or chemical engineering. Student interests are diverse, though the majority of students are interested in the medical aspects of biological engineering. Hands-on design projects are chosen with wide appeal in mind to spark the interest of students regardless of their specific area of interest.

Both courses focus on engineering fundamentals, and hands-on, project-oriented group work. Written, oral, and teaming skills are also stressed, and BE 1252 is the freshman level WAC course designated as writing and communication intensive.

More specific information about each course is contained in the sections below.

BE 1250: INTRODUCTION TO ENGINEERING METHODS

Overview

BE 1250 is a two credit hour (six hours laboratory per week) first semester freshman core course that focuses on the fundamentals of engineering design; presentation of an engineering design; and graphical expression of engineering design using computer-aided drafting. Students who complete the course must:

- demonstrate an understanding of the engineering design process
- communicate an engineering part or assembly design using graphics
- gain an understanding of biological engineering
- develop, construct, test, and demonstrate a project as a team.

Students spend the first half of the course learning engineering graphics concepts on AutoCAD®. Students work in randomly assigned groups of three to four students during the second half of the course to design and construct a device.

The criteria for grade determination include 50% for engineering drawing homework assignments, 25% for design, construction, testing, drawing and reporting on the team project, 20% for the final exam, and 5% for participation.

Description

Students spend the first seven weeks of the semester primarily in the computer laboratory on individual work stations. They receive instruction on engineering graphical concepts for the first portion of the class time, and are then given in class time to complete an assignment that uses the graphical concepts presented. The assignments are progressively difficult and provide the student with the proficiency to use most of the 3-D capabilities of AutoCAD. Students are introduced to the field of biological engineering through visits to research laboratories in the department. A scavenger hunt is held to familiarize students with the building and the support staff and faculty in the department.

The second half of the course is taught in the shop and fabrication facilities, and the students work in teams to construct a device. This hands-on experience is intended to teach the following concepts:

- working as a team
- fabricating items (materials and processes)
- the engineering process
- creativity
- safety
- economics
- testing procedures.

Students are required to design and construct a Rube Goldberg machine or a catapult. The Rube Goldberg machine follows the national contest objectives and rules. The students are to design a device to accomplish a goal (e.g. selecting, washing, and peeling an apple) in twenty unique steps, in which each step requires a transfer of energy. At the end of the semester the students demonstrate the effectiveness of their design in two trials. The designs are scored based on achieving the goal, and the uniqueness and quality of the design. Another term project used in some offerings of this course is the construction of a catapult device designed to throw water balloons. Limits are set on the size of the device and amount of weight for safety reasons. At the end of the term, each team competes in three categories: longest throw, most accurate throw, and 'war' whereby teams try to hit an opponent's catapult (based on a tournament-style bracket) in a timed event. In all cases the balloon must break to count. Points allotted to the first, second and third place teams in all three competition categories are combined with scores for the theme of the device, the adherence to

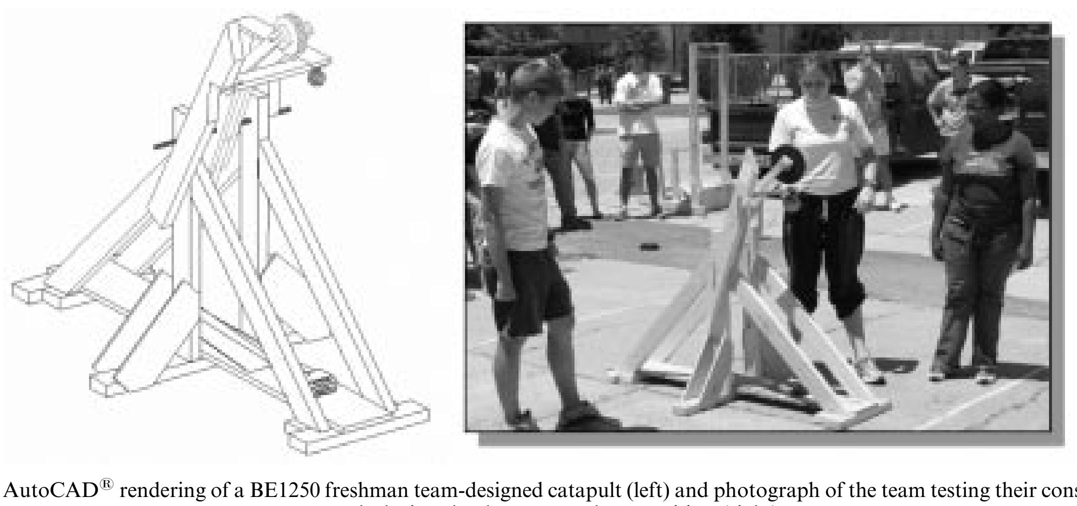

Fig. 1. AutoCAD® rendering of a BE1250 freshman team-designed catapult (left) and photograph of the team testing their constructed catapult during the departmental competition (right).

contest rules, and the fabrication skill demonstrated by each group. Common to both types of projects is the requirement to draw a 3-D assembly drawing of the design in AutoCAD (Fig. 1).

Specific topics taught in BE 1250
- A brief history of engineering
- Overview of the engineering design process
- Current research projects in biological engineering laboratories
- Engineering graphics concepts
- Drawing and dimensioning in AutoCAD (in two and three dimensions)
- Methods of fabrication and assembly.

BE 1250 course deliverables
- Homework assignments illustrating engineering graphics concepts
- Final, written project report, including AutoCAD assembly drawing
- Constructed, tested device.

BE 1252: BIOLOGY IN ENGINEERING

Overview

BE 1252 is a two credit hour (one hour lecture, three hours laboratory per week) second semester freshman core course that focuses on the effect of variability and constraints of biological systems on engineering problem solving and design; engineering units; engineering report writing; oral report presentation; and laboratory demonstration of biological engineering analysis. The majority of learning experiences in the course are integrated into a semester-long, service-learning, group project to highlight the connection between engineering and service to society, to develop civic responsibility, and to provide hands-on, real-world, community-based experience.

The instructor assigns groups of three to four students based on individual interest in the project and group learning techniques [9]. Another critical component of assigning groups is previous or co-enrollment in BE 1250; each team has at least one member that is comfortable with using AutoCAD. This is critical because the final design project must be drawn in AutoCAD.

Grades are calculated using the following rubric:

- Midterm exam: 20%
- Quizzes (lab attendance is one quiz score): 20%
- Student portfolio: 25%
- Group design project: 20% (10% individual contribution, 10% group grade, grades determined in consultation with community partner)
- Final exam: 15%

Description

Service-learning is defined as 'A credit bearing educational experience in which students participate in an organized service activity that meets identified community needs and reflect on course content with a broader appreciation of the discipline and an enhanced sense of civic responsibility' [10]. Service-learning is used to illustrate to students the explicit ties between the engineering work that they do and how this work is vital to the local community and to society.

The project emphasizes 'big picture' concepts involved in design, including the engineering design method, methods of evaluating decisions, the importance of communication in the design process, and consideration of different perspectives and how they affect a design. Community-based,

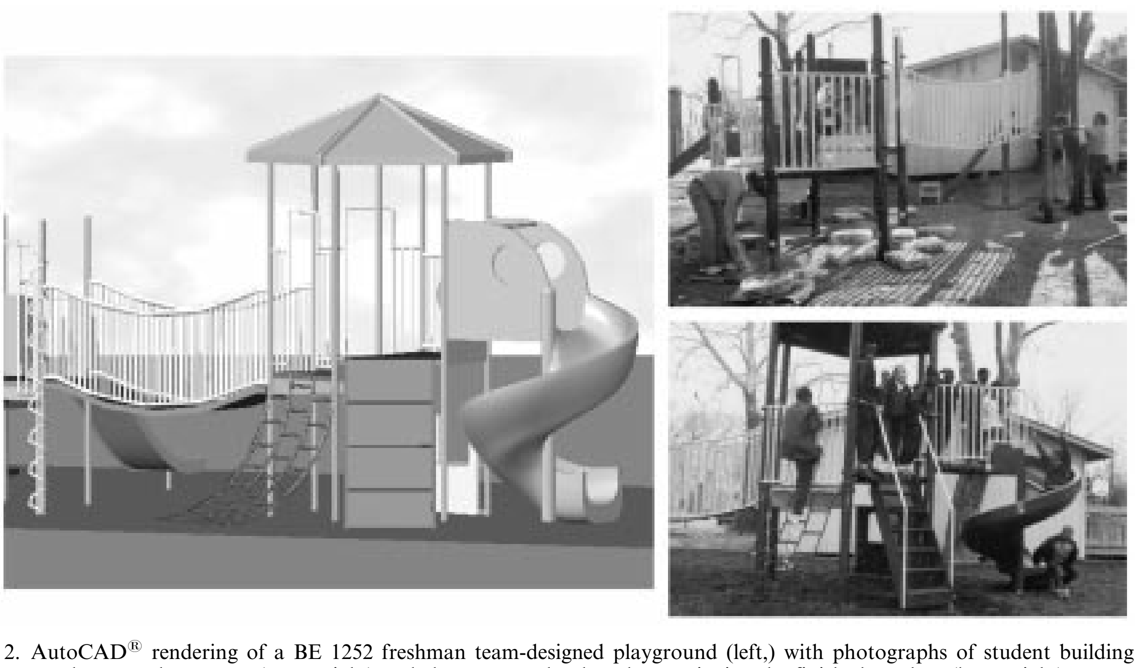

Fig. 2. AutoCAD® rendering of a BE 1252 freshman team-designed playground (left,) with photographs of student building the playground structure (upper right) and elementary school students enjoying the finished product (lower right).

service-learning projects are assigned to ensure that students can put their knowledge of the relationships between engineering design and social context into practice. Design projects are selected based on needs of the local community, relevance to biological engineering, potential interest in the project for students and instructor, and the willingness of the community/community partners to work with students. Service-learning projects are focused on building infrastructure at K-12 public schools, for example, outdoor classrooms and butterfly gardens. The primary focus has been the design and construction of playgrounds at elementary schools (Fig. 2).

The service-learning project is introduced to students during the first week of the course; the first half of the semester is spent with instruction on the specific design project and other information gathering exercises such as field trips, library and Internet searches, and speaking with experts and community partners. The second half of the semester is spent developing and evaluating designs with the input of the community partner, then preparing AutoCAD drawings and specifications, including cost estimates. At the end of the semester, designs are evaluated by expert review panels and the community partners. Each group presents a separate design so that community partners are able to choose which aspects of each design they most desire, thereby creating a consolidated design for eventual construction.

For a more detailed model of this course with a focus on service-learning issues, consult Lima [11].

Specific topics taught in BE 1252

- Introduction to engineering
- Overview of biological engineering
- Defining the service-learning problem to be addressed
- The engineering design method
- Working with teams and community partners
- Playground safety standards, liability issues, and the ADA
- Rudimentary design methods
- Written communication skills (focus on reports and proposals)
- Leadership and conflict resolution skills
- Oral communication skills.

BE 1252 course deliverables

Student work is collected and organized into a student portfolio (for details see [12]). This portfolio contains all of the work the student completed in the course, including:

- a detailed report on an area of biological engineering research in which they are interested
- individual homework assignments, tests, and quizzes on course material
- group assignments specific to the design project;
- journals in which students reflect on specific aspects of their course experiences
- a copy of the final design in AutoCAD and corresponding report for the community partner
- a copy of the PowerPoint® presentation made to the community partner and expert panel
- a final reflection on the course including confidential assessment of each group member, a self-assessment, and an assessment of the final design.

Consolidated designs are constructed when the money to build the design is obtained. Approximately 30% of students formerly enrolled in the course volunteer to complete the construction process.

RESULTS AND DISCUSSION

We believe that the freshman engineering model presented in this paper is a success for our students and our curriculum. We base this assertion on several parameters, including student retention and graduation rates, student assessment and reflection, exit interviews, and faculty reflections. Each of these parameters will be discussed in more details in the sections below.

Student retention rates

Freshman retention rates, the percentage of freshman that returned to the same department their second year, were compared between BE and the other engineering programs at LSU from 1993 to 2002. Results of this analysis show that in 1994, prior to restructuring of the BE curriculum and freshman model, the retention rate of freshman in BAE was 57%, below the same year rate for freshman in the college of engineering at LSU (61.6 ± 7%, mean ± standard deviation). The most recent data tabulated (2002) indicate that the freshman retention rate in BE was 72%, significantly above the mean of other departments in the college (59.6 ± 9%). General trends between the retention rates in the BE program and the rest of the college of engineering are shown in Fig. 3. Retention data were also obtained for freshmen women for the same time periods (Fig. 4). In 1994, the percentage of freshmen women continuing studies in the BAE department was 50%, below the same year rate for freshmen in other engineering departments (73.6 ± 22.8%). Most recent data show that in 2002, 86% of women in the BE freshman courses stayed in the curriculum for their sophomore year, significantly above female retention rates in other engineering programs (62.6 ± 15.8%).

Graduation rates

Departmental graduation rates were also collected for students in the program and compared for differences since the inception of the freshman model and curriculum overhaul. Five-year graduation rates, the percentage of students who graduated from the departmental

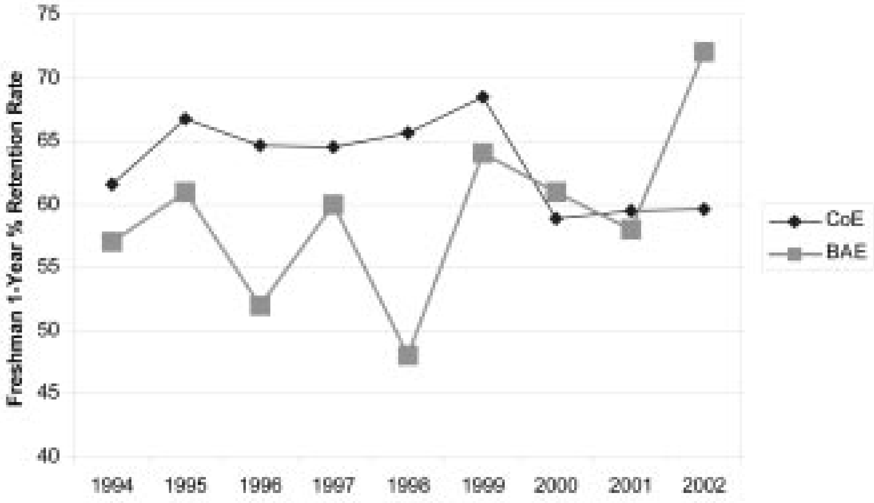

Fig. 3. Comparison of 1-year retention rates between freshmen in the LSU BAE department and the LSU College of Engineering.

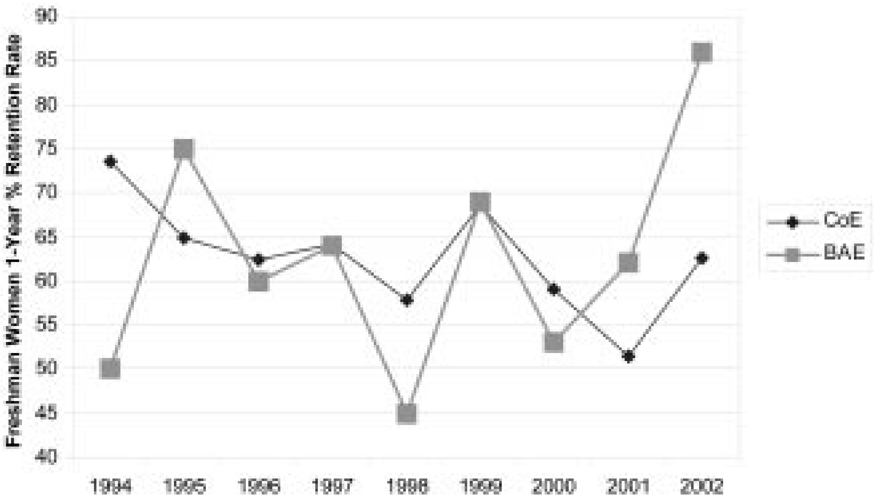

Fig. 4. Comparison of 1-year retention rates between freshmen women in the LSU BAE department and other departments in the LSU College of Engineering.

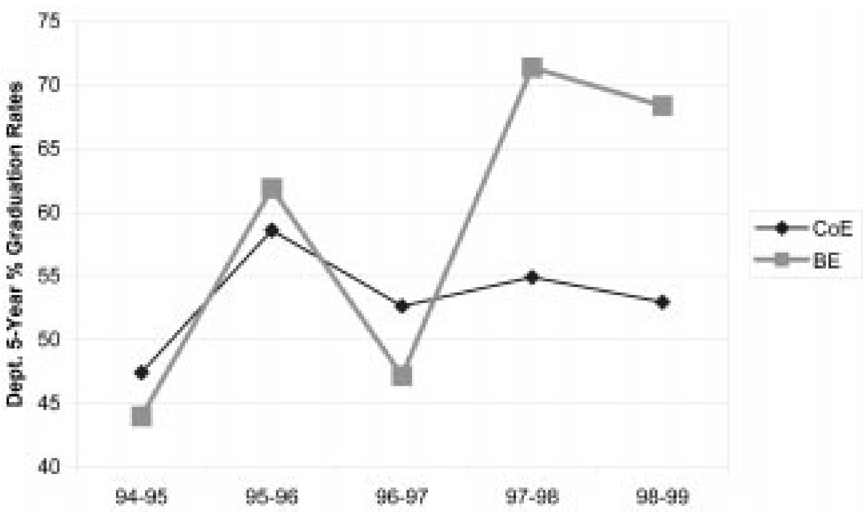

Fig. 5. Comparison of 5-year graduation rates between students in the LSU BAE department and other departments in the LSU College of Engineering.

program within five years of enrolling at LSU, were compared to rates in other departments in the college (Fig. 5). Of students enrolling during the 1994–95 academic year, 44% in the BAE program graduated within five years, compared to 47.4 ± 9.9% in other departments. Most recent data (1998–1999) indicate a 68.4% graduation rate of students, significantly above the college mean graduation rate of 52.9 ± 8.9%. More recent three and four-year graduation rates are consistent with three and four-year rates observed in the 1998-99 period (data not shown). These data suggest that five-year graduation rates will continue on this upward trend.

The retention and graduation rates for students in the BE program indicate an improvement since the freshman model and curriculum overhaul were implemented. In addition, retention rates for freshmen women have increased and are currently higher than any department in the college.

Student assessment and reflection

Student evaluation of the freshman program can yield important information about the courses, such as the quality of the learning experience and how the course might be improved. Students are asked to express their course experiences in writing. Several representative quotes are included below.

> 'I learned that when talking to people for advice regarding the design of something, you will often get contradictory opinions. Different people will look at the same design from different angles depending on their experience . . .'

> 'In working with the . . . (K-5) students, I was able to more fully understand how engineering works, and learning to understand that there are more than numbers, figures and statistics to engineering.'

> 'I also learned that designing something for someone is not as easy as I thought. You have to consider cost, area, stipulations, ADA (Americans with Disabilities) regulations, your clients, time, materials and dimensions. It's a whole lot to consider.'

> 'I learned about the importance of perspective in engineering. I had to think like a child to design the best playground. I had to think like a parent to design a safe playground. I had to think as a member of the community to design a playground that reflected the unique aspects of the community. I had to think like a politician to sell the playground to potential funders.'

> 'The community had to communicate to us what they needed, and then we had to communicate in our groups effectively to solve the problem. Then we had to communicate back to the community and show our designs and get feedback. It's constant communication that you need for designing something.'

In terms of more formal student assessment, Ropers-Huilman *et al.* conducted research to determine if service-learning effectively met a-k objectives for BE 1252 [13]. One measure involved a survey of students to determine the extent to which the service-learning project in BE 1252 met each a–k objective. Results are contained in Table 1. The table also summarizes course activities assigned by the instructor that specifically address each ABET learning objective.

Students indicated that BE 1252 met all ABET learning objectives at least moderately, and believed that the course was especially useful for meeting objectives on communication, teamwork, formulating and solving engineering problems, and designing a system, component or process to meet desired needs. Though this research did not extend to BE 1250, it is encouraging to note that the objectives that students ranked strongly are also focus areas of BE 1250.

Exit interviews

The department chairs have performed exit interviews with graduating students for the past ten years that assess both specific courses and overall experiences from the program. A qualitative assessment of these records indicates that students' opinion of the freshman program and curricular change has been a positive one. Specifically, they feel that the freshman engineering program has helped to associate students with the BAE department (including procedures, facilities, staff, and faculty) and their peer BE students, and helped familiarize them with the curriculum and field of biological engineering as a whole. Students from this program commented that the instructors at the freshman level have a large impact on their experience and also their decision to continue within the program. Attention from instructors helped bridge the transition to college for those students with lesser secondary education preparation. A surprising result from the exit interviews was how many students transfer to BE based on the recommendations of their peers. High-impact projects such as the Rube Goldberg, catapult, and playground projects serve to recruit students from other departments and from outside of engineering as well. Students mentioned that without access to freshman engineering courses, this word-of-mouth opportunity would decrease due to reluctance to changing major after a few years in their respective programs.

Faculty reflections

We believe that the establishment and execution of the freshman engineering program has been successful for our students, faculty, and program. There is a significant program focus on students identifying their career goals and motivations and researching career-based information on biological engineering. While this approach causes a significant percentage of students to leave the program as freshman, we believe that the career focus is a strength of the program because students make well-informed career decisions in the initial stages of their college lives. Our goal is not retention for retention's sake, but retention of students who are truly interested in biological engineering. This approach helps instructors from the sophomore

Table 1. Example of activities in BE 1250 and BE 1252 that address the ABET a-k objectives. Note: Moderate means that 26–59% of students rated service-learning as very useful for helping them meet the objective, and strong indicates that 60% or more rated service-learning as very useful for addressing the objective.

Does the course contribute to this outcome:	1250	BE 1250 Examples	1252	BE1252 Examples	BE 1252 Student feedback on extent objective was met
(a) An ability to apply knowledge of mathematics, science, and engineering	YES	Homework assignments require mathematics to calculate distances and angles. The design project uses physics and some biology	YES	Homework and lab assignments, exam questions in which the student must use principles of engineering units and playground design standards to design a playground.	moderate
(b) An ability to design and conduct experiments, as well as to analyze and interpret data	NO		YES	Students collect playground data (measurements) and compare to standards and playground evaluation rubric.	moderate
(c) An ability to design a system, component, or process to meet desired needs	YES	Term design project—students design catapults or Rube Goldberg contraptions	YES	Homework, laboratories, quizzes, exam, and final report/presentation show the ability of students to design a playground.	strong
(d) An ability to function on multi-disciplinary teams	YES	Students are organized into teams for the term project.	YES	Students work in teams throughout the semester, learn about and are tested on teaming and conflict resolution skills.	strong
(e) An ability to identify, formulate, and solve engineering problems	YES	This is a focus of the design project	YES	Students meet with community partners to frame project and problem solving, conduct critiques of existing playgrounds, and learn to critique potential sites for playgrounds through lab and homework exercises.	strong
(f) An understanding of professional and ethical responsibility	YES	In-class discussions on professional activities, ethics of copying published designs.	YES	Discussions and test questions on the Americans with Disabilities Act and the Consumer Product Safety Commission with playground design are largely based on safety and ethical issues.	moderate
(g) An ability to communicate effectively	YES	Students are required to explain their projects to the class and guests	YES	Class instruction on oral, written and team communication. Students are tested on these principles in exams, and must complete numerous oral presentations to peers, expert panel, and community partner.	strong
(h) The broad education necessary to understand the impact of engineering solutions in a global and societal context	YES	In-class discussions on why biological engineering is important to community and global well-being	YES	Students are tested on these concepts based on reading, notes, and in class discussion on topics such as lifecycle design, engineering and community history, safety, ethical and ADA issues, and whole child development.	moderate
(i) A recognition of the need for, and an ability to engage in life-long learning	NO		YES	Students learn historical development of playgrounds and how recent and current laws (ADA, CPSC, safety recalls) continue to refine engineering standards.	moderate
(j) A knowledge of contemporary issues	YES	Discussion of current BE research topics and lab tours	YES	Students learn about engineering, non-technical issues that affect engineering, and how to work with community partners, which includes learning the history and culture of the community they are working with.	moderate
(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	YES	Graphical expression of engineering design.	YES	Final playground project (oral/written) requires students to use techniques of engineering design and current engineering standards to effectively design a playground.	moderate

to senior levels because the students entering these classes are familiar with the discipline, their peers, and are motivated to continue in the curriculum.

Students benefit from the freshman sequence because they get to know one another from the initial stages of their college careers. The students tend to take the most difficult courses in the curriculum (in mechanical and civil engineering) together, and seem to perform better than other students enrolled in these courses by virtue of the strong support system they have developed for studying. These observations mirror results from studies on the impact of freshmen engineering courses that correlate graduation rates to first semester GPA's [14]. Student reflections indicate that they enjoy the hands-on aspects of the courses and state that the courses help them to determine if biological engineering is the discipline in which they are interested. Some students state that the idea of making a difference in the local community is really appealing to them.

From a faculty perspective, the freshman engineering sequence serves to combat stereotypes and myths, for example:

- Engineering is an exact profession, and there is always one correct answer to a problem
- All you need to be a good engineer is aptitude in math and science
- The technical part of problem-solving is the most important part, and drives most engineering decisions.

The students learn that cultural sensitivity is an integral part of the design process, learn about working together instead of working in isolation, and learn about how engineering can provide citizens the access to goods and services versus providing charity. In short, they learn the connection between being engineers and democratic citizens. We believe that the development of these tools early on in an engineering curriculum are essential for enabling students to more easily grasp the complexities and art of the engineering profession.

CONCLUSIONS

The freshman engineering model developed in biological engineering focused on addressing low retention rates and providing students with the opportunity to explore their career choices, meet their peers, familiarize themselves with the biological engineering department, and learn about engineering through the design and construction of hands-on, team projects. The program is considered an integral reason for the improvement of student retention and graduation rates. Students have indicated that meeting their peers and becoming familiar with the facilities and faculty are an important part of the program. Formal student assessment for BE 1252 indicate that the a–k learning objectives set forth by ABET are at least moderately met, and that the strongest learning focus is on developing communication skills, working in teams, identifying, formulating and solving an engineering problem, and designing a device, system, or product to meet desired needs. These objectives are a focus of both freshman courses from a faculty perspective, indicating that student learning experiences are consistent with faculty intentions in this regard. We believe that the freshman engineering program is an important means for providing a context for students to understand the theoretical information they are learning in math and basic science courses, and for illustrating the complexities and art of the engineering profession.

Acknowledgements—The authors gratefully acknowledge Alicia Abadie and Carla Haslauer for collecting information on freshman engineering programs in the United States and abroad, and Michel Schexnayder from the LSU Office of Budget and Planning and Angela Singleton for providing retention data and technical assistance in the preparation of this manuscript. Richard Bengtson and Dan Thomas reviewed the manuscript. Salaries and research support were provided in part by the LSU Agricultural & Mechanical College, the LSU AgCenter, by NSF EPS-034611 (through the Center for Biomodular Multi-Scale Systems), and by the State of Louisiana Board of Regents Support Fund. This publication was approved by the Director of the Louisiana Agricultural Experiment Station as manuscript number 05-16-0110. Reference to commercial products or trade names does not imply endorsement or discrimination by the LSU AgCenter or LSU Agricultural & Mechanical College.

REFERENCES

1. K. L. Watson and M. R. Anderson-Rowland, Interfaces between the foundation coalition integrated curriculum and programs for honors, minority, women, and transfer students, *Proc. Frontiers in Education Conf.*, 1995.
2. F. Jeffrey and K. Frair, Theoretical foundations for the Foundation Coalition Core Competencies, *Proc. ASEE National Conf.*, St. Louis, MO, 18–21 June 2000.
3. J. C. Collins and T. R. Harris, The VaNTH ERC: a vehicle for continuing education in bioengineering, *Industry and Higher Education,* **15**(5), 2001, pp. 333–339.
4. D. Hanesian and A. J. Perna, A change in the freshman engineering education paradigm: bringing engineering design up-front in the curriculum, *Proc. Int. Conf. Engineering Education* (ICEE 2000), 14–16 August.
5. T. McElwee, *Personal Communication on Market Research* (2004).
6. C. T. Abdallah and P. Dorato, A survey of engineering education outside the united states: implications for the ideal engineering program, *Proc. ASEE Gulf-Southwest Section Annual Meeting*, Albuquerque, NM, March 1992.

7. R. Bengtson, Louisiana State University's Biological Engineering Program, *Int. J. Eng. Ed.,* 2006. This issue.
8. M. Lima, C. Drapcho, T. Walker, R. Bengtson and L. Verma, A model for integrating [communication] skills across the biological engineering curriculum, *Int. J. Eng. Ed.,* **17**(1), 2001, pp. 67–74.
9. B. Davis, Collaborative learning: group work and study teams, in: *Tools for Teaching*, San Francisco, CA: Jossey-Bass Publishers (1993).
10. R. Bringle and J. Hatcher, A Service-Learning curriculum for faculty, *Michigan J. Community Service Learning,* **2**(3), 1995, pp. 112–122.
11. M. Lima, Service-Learning: A unique perspective on engineering education, in *Projects That Matter: Concepts and Models for Service-Learning in Engineering,* E. Tsang (ed), AAHE's Series on Service-Learning in the Disciplines, AAHE Press, pp. 109–118 (2000).
12. A. Christy, and M. Lima, The use of student portfolios in engineering instruction, *J. Eng. Ed.,* **87**(2), 1998, pp. 143–148.
13. R. Ropers-Huilman, L. Carwile and M. Lima, Service-learning in engineering: a valuable pedagogy for meeting learning objectives. *Eur. J. Eng. Ed.,* **30**(2), 2005, pp. 155–165.
14. D. D. Budny, G. Bjedov and W. LeBold, Assessment of the Impact of the Freshman Engineering Courses, *J. Eng. Ed.,* Oct. 1998, pp. 405–413.

Todd Monroe graduated in one of LSU's first Biological Engineering degree classes in 1996, and is pleased to have the opportunity to serve as an Assistant Professor in Biological and Agricultural Engineering at LSU since 2002. Prior to this time, his graduate and postdoctoral work was in the Biomedical Engineering Department at Vanderbilt University. His research focuses on molecular and cellular level bioengineering, including design and control of DNA probes, BioMEMS, and implantable sensors. He has been recognized at the university level for teaching performance in his freshman BE 1250 section and senior/graduate courses in biomechanics and molecular engineering technologies.

Mike Mailander is an Associate Professor in Biological and Agricultural Engineering at Louisiana State University. He received his Ph.D. from Purdue University in Agricultural Engineering. He teaches freshman and senior level courses, and has coordinated international senior design teams. His research focus is on sensors, controls and alternative energy. Dr. Mailander also serves as the department's graduate coordinator.

Marybeth Lima has been at LSU since 1996, and has been teaching BE 1252 for ten years. Her research interests include biological engineering, engineering education, and the practice of engineering as it relates to social justice and change. She has been nationally recognized for her work in service-learning in engineering by the American Society of Agricultural Engineers, the American Society for Engineering Education, and the New England Resource Center for Higher Education. Dr. Lima is the co-author of *Service-Learning: Engineering in Your Community*, a textbook for engineering students completing engineering and design projects within a community setting. This book was published by Great Lakes Press in 2006.