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First-Year Program Enhancements at Liberty University

Prof. James Lloyd Long, Liberty University

Currently serving as Assistant Professor of Engineering at Liberty University, specializing in Introduction to Engineering, Technical Communications, Engineering Economy, and Probability and Statistics for Engineers. Retired from the U. S. Navy after nearly 23 years as a submarine warfare officer; served as the Fleet Protocol Officer during the first Iraqi War (Operation Desert Shield / Desert Storm). Certified as a Project Management Professional with 20 years experience in the commercial nuclear power industry and the radio broadcast industry. Married to Roxanne for 46 years, two children, five grandchildren. Resides in Lynchburg, Virginia.

Mrs. Carolyn Ziebart, Liberty University

Work-in-Progress – First Year Program Enhancements at Liberty University

James L. Long, Carolyn W. Ziebart
Liberty University, jllong2@liberty.edu, cziebart@liberty.edu

***Abstract* - Liberty University's School of Engineering and Computational Sciences was established in 2007 and currently offers undergraduate programs in Computer Engineering, Electrical Engineering, Industrial & Systems Engineering, Mechanical Engineering, and Computer Science (with four cognates), as well as a graduate program in Cyber Security. The First Year Engineering program has recently completed the third year of an ongoing initiative to transform it from a 'make or break' mindset to one more focused on preparing the incoming students for success in their engineering programs, which is the focus of this 'work-in-progress' report. A number of new active learning pedagogies have been implemented in the Introduction to Engineering course to provide a greater focus on critical thinking, metacognition, and acquisition of effective student learning skills. Additionally, a number of student success initiatives have been instituted and additional initiatives are planned for the future. The results, while not yet up to the levels typically cited at the First Year Engineering Experience annual conference, have nonetheless been encouraging and are discussed in this report.**

Index Terms – First-year engineering, Design Your Own Plan, Master student, Cooperative learning

HISTORY OF ENGINEERING PROGRAMS AT LIBERTY

The School of Engineering and Computational Sciences (SoECS) at Liberty University was established in 2007, initially offering four engineering programs serving an incoming freshman class of 44 students. The first Electrical Engineering, Software Engineering, and Industrial & Systems Engineering graduates received their degrees in 2011, with the first Computer Engineering graduates following in 2012. Although the Software Engineering program was subsequently dropped, the Electrical and Industrial & Systems Engineering programs received ABET accreditation in 2012, followed by Computer Engineering in 2013. The Mechanical Engineering program was started in 2014 and is on track to have its first graduates in 2018, with ABET accreditation to follow. Civil Engineering is tentatively planned for startup in the 2018-19 school year. Incoming freshman class size has grown steadily, reaching a peak enrollment of 249 declared engineering majors in the 2015-2016 school year.

From its inception, the entry point for the engineering programs at the SoECS has been ENGR 110, Introduction to Engineering and Problem Solving. This course introduces engineering neophytes to the principles of problem solving, critical thinking, programming concepts, engineering ethics, and the engineering design process. Students enrolled in the course must function at a precalculus or higher level of mathematics, which may be satisfied by concurrent enrollment. There are currently no restrictions to students declaring engineering as their major.

This initial program setup assumed that students entering their freshman year of college were adequately prepared for the rigors of the engineering programs. However, over the ensuing years, it became obvious that this was not the case, as evidenced by high freshman to sophomore attrition rates and low graduation rates. This lead to a decision by the Dean of the SoECS to appoint a first-year programs coordinator (JLL) and challenged him with improving freshman to sophomore persistence rates. The first order of business was to get 'plugged in' to the First Year Engineering Experience (FYEE) movement, starting with attendance at the 6th Annual FYEE Conference hosted by Texas A&M University. It was at this conference that the coordinator first met Ray Landis and became aware of the importance of preparing students for success in their engineering education. Exposure to the variety of pedagogies and program initiatives being employed across a broad spectrum of engineering schools led to a number of changes being implemented to the Introduction to Engineering course in the Fall 2014 term, with additional changes to program infrastructure, teaching pedagogies, and student success initiatives in the subsequent terms.

TEACHING PEDAGOGIES IMPLEMENTED

Significant changes to teaching resources and pedagogies implemented in the first-year engineering programs over the past three years include:

- **Adoption of *Studying Engineering: A Road Map to a Rewarding Career*.** Ray Landis' seminal work [1] was established as a foundational text in the Introduction to Engineering course. In-class discussions and out-of-class reflective writings serve to instill and reinforce the attributes of a master learner into the engineering students.
- **Addition of the 'Design Your Own Plan' project:** Development of an individual success plan serves as the culminating student development activity in Introduction to Engineering course. This project focuses on the student's educational and professional goals and the

plans to achieve them, including self-evaluation and improvement activities in the areas of community building, professional development, academic development, and personal development.

- **Active learning techniques:** Traditional lecture format classes have been augmented with an array of active learning techniques, including think-pair-share, group problem solving, and individual and team readiness assessment quizzes.
- **Metacognitive & reflective activities:** Activities designed to cause students to think deeply about how they learn have been introduced to enhance the learning experience, including exam wrappers, regrade petitions, and reflective writing assignments.
- **Focus on critical thinking skills:** Techniques associated with looking at all sides of an issue and fairly arriving at a reasoned conclusion stress the importance of process in decision-making. These include how to identify the elements of reasoning and the intellectual standards by which to evaluate them.

PROGRAM INFRASTRUCTURE INITIATIVES

A number of key infrastructure initiatives demonstrated the administration's commitment to strengthening the first-year programs success, including assignment of dedicated first-year program faculty and addition of active learning classrooms and facilities.

- **Dedicated first-year faculty:** Prior to the improvement initiative, engineering faculty were assigned to teach the ENGR 110 course based primarily on availability. The assignment of a coordinator to implement changes to the program in the 2014-2015 school year also signified the establishment of dedicated faculty to the first-year programs. A second full-time first-year engineering faculty member (CWZ) was added in the 2015-2016 school year and full-time computer science and technical communications faculty were added to the first-year programs staff in the 2016-2017 school year. The first-year faculty have been fully engaged in the FYEE annual conference and other engineering education conferences, workshops, and training activities since 2014.
- **Active learning facilities and equipment:** The 2014-2015 school year also saw an expansion of SoECS facilities, including the addition of active learning classrooms, a MakerSpace featuring 3D printing and nanotechnology capabilities, and a machine shop featuring a variety of equipment. Additionally, in the 2015-16, the authors received a grant for the provision of Arduino microprocessor kits for use in the Introduction to Engineering course. The first-year programs have made full use of these new facilities and equipment.

STUDENT SUCCESS INITIATIVES

A number student success initiatives have been implemented to supplement the First-Year Program changes, including changes to the student advising protocols and establishment of a number of mechanisms for upper class engineering students to interface with the freshmen.

- **Embedding professional advisors.** Two professional advisors who are specially trained in the path to completing the engineering degree programs serve the SoECS community, with offices located within the SoECS facilities. Professional and faculty advising sessions are mandatory for each engineering student prior to registration for every fall and spring term.
- **Establishment of a Freshman Mentoring program.** Junior and Senior engineering students serve as mentors to groups of freshmen to assist them in navigating the complexities of university life in an engineering context. Mentoring activities include periodic encouragement via email and 3-4 group meetings per term.
- **Creation of an Engineering Emporium.** Volunteers and paid student workers serve as tutors for engineering, math, and science subjects in small group recitation sessions at regular times during the school week. Special focus is given to current class projects and upcoming exams.

RESULTS TO DATE

Table I displays the data from the baseline year of 2013-2014 (the last year of the 'make or break' approach) and the three years subsequent to implementing the student success approach discussed above.

TABLE I
SUMMARY OF RESULTS

	2013 - 2014	2014 - 2015	2015 - 2016	2016 – 2017	4-Year Average Change
ENGR 110 Initial Enrollment:	115	176	214	183	+76.0
Withdrew Before Completion:	14	13	18	10	-0.03
ENGR 110 Final Enrollment:	101	163	196	173	+76.3
Total Passed (≥C) ENGR 110:	87	150	184	155	+80.3
ENGR 110 Gross Pass (≥C) Rate:	75.7%	85.2%	86.0%	84.7%	+9.7%
Enrolled in Engineering Next School Year:	58	119	145	126	+72.0
Gross Engineering Persistence Rate:	50.4%	67.6%	67.8%	68.9%	+17.6%
Net Engineering Persistence Rate:	66.7%	79.3%	78.8%	81.3%	+13.1%
Enrolled at LU Next School Year:	84	145	190	164	+82.3
Gross LU Persistence Rate:	73.0%	82.4%	88.8%	89.6%	+13.9%

Notes:
- Gross engineering persistence rate represents the percentage of students initially enrolled in ENGR 110 in one school year continuing in an engineering major in the next school year.
- Net engineering persistence rate represents the percentage of students passing (with a grade of C or better) ENGR 110 in one school year continuing in an engineering major in the next school year.

- Gross LU persistence rate represents the percentage of students initially enrolled in ENGR 110 in one school year continuing at Liberty University in the next school year.
- ENGR 110 gross pass rate represents the percentage of initially enrolled students achieving a final grade of C or better
- 4-Year Average Change calculated as average value from 2014-2017 minus the 2013-2014 value.

Key observations from Table I:

- Gross persistence rate prior to implementation of course changes was effectively 5 out of 10 (50.4%), whereas the post-change rate is approaching 7 out of 10 (68.9% in the most recent year).
- Net persistence rate prior to implementation of course changes was effectively 2 out of 3, whereas post-change rate is approaching 4 out of 5.
- Overall persistence rate at the university has improved from 7.3 to nearly 9.0 out of 10, demonstrating that even if a student doesn't continue as in engineering, an increasing number are remaining in the university rather than dropping out.

Not reflected in Table I is the effect of the changes on graduation rate. While the data is still preliminary regarding this important parameter, it is significant to note that the baseline data school year (2013-2014) produced only 20 engineering graduates, whereas the first year following implementation of the changes to the first-year program (2014-2015) has 61 students entering the Senior Design Capstone sequence in the upcoming (Fall 2017) term.

Analysis

An ANOVA analysis of the data was conducted in three stages. The first analysis assumed a null hypothesis that the mean proportion of the parameter under analysis was equal across each of the four years ($p_1 = p_2 = p_3 = p_4$). The second analysis evaluated a similar hypothesis across only the first two years ($p_1 = p_2$). The third analysis evaluated a similar hypothesis across only the latter three years ($p_2 = p_3 = p_4$). The p-values resulting from these three analyses are shown in Table II. This analysis supports the contention that the shift from a 'make or break' approach to a 'student success' model has been statistically significant.

TABLE II
ANOVA P-Value Results

	Analysis 1	Analysis 2	Analysis 3
Gross Engineering Persistence Rate:	**0.0042*** **	**0.0032*** **	0.9620
Net Engineering Persistence Rate:	0.0860*	0.0307**	0.2894
significant to a level of ***0.005**, **0.050, *0.100			

Study Limitations

The purpose of the initiative was to increase freshman to sophomore persistence and once it was determined that the biggest need was to change the overall approach from a 'make or break' model to a 'student success' model, multiple changes were implemented as a package, thus limiting the ability to discern the precise impact of each individual element. Also, while the results appear to be statistically significant, it is possible that factors outside of the SoECS had a bearing on the results observed. These potential factors have not been identified nor considered in the analysis.

Future Plans

Two new initiatives are planned for implementation in the upcoming Fall 2017 term.

- **Addition of ENGR 102, Introduction to Engineering and Computer Science.** Under the current program structure, not all first-year students are eligible to enroll in the ENGR 110 course, usually because of math deficiencies. It is likely that a significant proportion of those students drop their engineering major designation before they are eligible to take ENGR 110. Thus, a new one credit hour course, ENGR 102, Introduction to Engineering and Computer Science will be offered starting in the Fall 2017 term and will be required of all students in their first semester as an engineering major, regardless of their level of math preparation. This course will focus on preparing the incoming students for success in their engineering programs and will culminate with the 'Design Your Own Plan' project. The expected impact of this new course will be to further enhance the persistence, retention and, ultimately, increased graduation rates of engineering students.
- **Adoption of a cooperative learning approach in ENGR 110.** With the movement of student success skills into the new ENGR 102, the current ENGR 110 course will be renamed Introduction to Engineering Fundamentals and will adopt a more structured cooperative learning approach, with the desired outcome of providing the students with a positive experience with successful high-performance teams. The primary model for this initiative is outlined by Felder and Brent [2].

Acknowledgment

The authors would like to acknowledge their appreciation to Ray Landis for his passion, vision, leadership, wise counsel, and encouragement throughout the past three years and to the FYEE leadership, contributors, and peers for the resources, inspiration, and continued efforts to improve first-year engineering programs.

References

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[2] Felder, R. M. and Brent, R. *Teaching and Learning STEM: A Practical Guide*, John Wiley & Sons, Inc., 2016, pp. 217-242.

Author Information

James L. Long, Assistant Professor of Engineering, Liberty University, jllong2@liberty.edu

Carolyn W. Ziebart, Instructor of Engineering, Liberty University, cziebart@liberty.edu