Towards IDEAL Engineers: Identifying and Developing Engineers as Leaders

Betsy F. Willis, Mark Fontenot, and David A. Willis
Southern Methodist University, bwillis@lyle.smu.edu, mfonten@lyle.smu.edu, dwillis@lyle.smu.edu

Abstract **- Industry and government entities have sounded the alarm indicating that the United States needs more engineering and computer science graduates. Graduates need to be prepared not only in their technical discipline, but also in the "softer" skills. The first two years of undergraduate engineering study have continually been a stumbling block for programs and students across the nation, thus causing a relatively significant attrition rate as compared to other academic majors. At Southern Methodist University, we developed the IDEAL (Identifying and Developing Engineers as Leaders) Scholars program aimed at improving retention of financially needy students through the first two years of study. Throughout the past four years, we have incorporated a number of activities and program components to increase engagement of three cohorts of IDEAL Scholars with engineering faculty and with their peers, to prepare students to take leadership roles in projects and student groups, and finally to retain them through the first two of their undergraduate years. Data collected at various points throughout the program indicate positive effects for many of the programmatic aspects. The goal of this paper is to share some of the lessons learned in the development of the IDEAL Scholars program.**

Index Terms – Student retention, leadership, living and learning communities, scholarship.

INTRODUCTION

In a statement released in December of 2012, President Obama called for a 1 million person increase in the number of STEM graduates over the next decade [1]. Between 2008 and 2018, the Department of Commerce projected a 17% increase in the number of STEM occupations versus only 9.8% increase in non-STEM occupations [2]. However, colleges and universities continue to see attrition from engineering and computer science with only about 50% of students intending majors in these fields attaining degrees [3]. Many studies have attempted to determine factors that are important to student retention in engineering majors. At Southern Methodist University (SMU), one third of first year students intending majors in engineering and computer science leave these majors before completing the required subset. Therefore, the first two years were identified as a critical period in which to retain students. Once students declared engineering and computer science majors at SMU, 94% of declared majors are retained into the junior and senior years.

Many research studies have examined factors affecting college student retention, and retention in engineering degree programs more specifically. In [3], Vogt examined the role of faculty in engineering students' performance and retention in engineering degree programs. The study showed that faculty distance (measured by survey items such as "interest in students" and "willingness to provide opportunities for students") had a negative impact on student self-efficacy and academic confidence [3]. The literature analysis of Deampfle also supports the concept that authentic faculty interaction has a positive effect on student retention for science, engineering, and mathematics majors [4]. Another way of increasing student engagement in their major is through a living-learning community. Informal student-faculty interaction as well as peer study groups have been shown to be higher for students in such a community [5].

Compounding the need for more STEM graduates is the need for graduates with professional skills necessary for the workplace. Employers are calling for the "employability skill" comprised of attributes such as work ethic, timeliness, attendance, and professionalism [6]. According to a study by the Center for Professional Excellence, 95% of both HR professionals and managers think colleges and universities should train students to enter the workforce with professional skills [7]. Suggested areas of training included internships, interviewing skills, communication skills, business/professional ethics, and workplace preparation/expectation.

PROGRAM DESCRIPTION

The IDEAL program at SMU was developed as a model to increase retention to matriculation into engineering/computer science degree programs and to develop leadership and professional skills. Students selected for the program showed high academic and leadership potential and demonstrated financial need. IDEAL Scholars received a scholarship and were required to participate in programmatic activities. The major program components included a weekly seminar, living in the Engineering Living and Learning Community (ELLC) and block scheduling. More detail on each is contained in the following:

- **Weekly Seminar:** A cornerstone of the IDEAL Scholars program, the weekly seminar provides an opportunity to engage in leadership development, to discuss common readings, to hear presentations by industry representatives, and to engage in community service. Leadership was developed in several ways. IDEAL Scholars led several of the seminars each semester, which required preparation of a presentation and associated materials. Topics varied from "How to Work a Career Fair" to "Tutoring Opportunities". The Scholars also had the opportunity to lead the discussion of common readings. Common readings included selections from Harvard Business Review such as "Crucibles of Leadership" [8] and "Discovering your Authentic Leadership" [9] as well as books such as "The Three Signs of a Miserable Job" [10] and "The Five Dysfunctions of a Team" [11]. The Scholars visited local public elementary schools a few different times to mentor students in after-school science and engineering-related projects. Presentations from industry included an IP attorney and a local tech entrepreneur. The IP attorney, an SMU alumnus, gave an overview of various types of IP and discussed a case pending (at the time) before the Supreme Court of the United States. The tech entrepreneur spoke on his decision to start his own company and the benefits and challenges of the world of entrepreneurship.
- **Engineering Living and Learning Community:** A major component of the IDEAL Scholars program is the requirement for all participants to live in the ELLC during their two years in the program. Over the years, the ELLC has been comprised of approximately 60 - 80 undergraduate engineering students ranging from first-year students to senior students. The resident assistants who are assigned to the ELLC have all been upper-division engineering undergraduates and hold the title of Engineering Resident Assistant, which requires that a portion of their programming be engineering themed. The ELLC is one of the most popular and active living communities on campus. The students self-form a wonderful sense of community by engaging in spontaneous study groups, close interaction with the Faculty-in-Residence, and informal peer mentoring and tutoring.
- **Block Scheduling:** Engineering and computer science students shared several common courses (but not necessarily common sections) during the first year including English I and II, Calculus I and II, and Principles of Computer Science. The undergraduate advising office arranged block scheduling for IDEAL Scholars in these courses so that students shared common sections. One of the program directors, who is also the Director of Undergraduate Advising and Student Records, advised all Scholars. Students were advised into the block-scheduled courses according to high school preparation and advanced placement credits.

METHODS

Three cohorts of IDEAL Scholars were selected from the pool of admitted engineering and computer science students for the incoming classes in Fall 2010, Fall 2011 and Fall 2012. The program directors worked closely with the Director of Undergraduate Recruitment and Retention for the Lyle School of Engineering at SMU. Three review phases were used to identify candidates for the program including (1) initial review, (2) file review, and (3) interview. During the initial review, admitted students who met the financial need and U.S. citizenship/residency requirements were screened for an intended major in engineering or computer science, and demonstrated academic excellence as determined by SAT/ACT scores, high school GPA and number of units completed. Application files of students selected during the initial review were read during the file review phase. Students were selected for an interview based on academic excellence as demonstrated by a rigorous math and science high school curriculum and demonstrated leadership experiences. During the interview phase, all candidates were asked a common set of questions aimed at gauging their level of interest in engineering and/or computer science as well as their views of and experiences with leadership. Scholars were selected from among the candidates interviewed.

IDEAL Scholars received a $10,000 per year academic scholarship and were required to participate in the program activities aimed at fostering academic excellence and developing leadership skills. To remain eligible for the program, students were required to maintain at least a 3.000 cumulative GPA at the conclusion of each spring semester and progress towards a baccalaureate degree in the Lyle School of Engineering as defined by completion of at least 12 credit hours towards the degree per fall and spring semesters.

Program results were collected from quantitative data and summative surveys at the conclusion of each spring semester. Quantitative data included demographics, time to engineering/computer science major declaration, and term and cumulative GPAs. IDEAL Scholars completed summative surveys at the end of each spring semester to provide feedback on program components and to gauge their leadership development.

RESULTS AND DISCUSSION

Three cohorts of Scholars participated in the program. Cohort A consisted of 9 students who entered college in the fall of 2010, Cohort B consisted of 8 students who entered in the fall of 2011, and Cohort C consisted of 11 students who entered in the fall of 2012. Each cohort

TABLE 1
IDEAL SCHOLARS' MAJORS

Cohort	CS*	CpE	EE	CE	EnvEng	MgtSci	ME
A	3	0	1	1	0	1	2
B	3	0	1	0	2	1	0
C	2	0	2	3	1	1	2
Total	**8**	**0**	**4**	**4**	**3**	**3**	**4**

*CS = computer science; CpE = computer engineering, EE = electrical engineering, CE = civil engineering; EnvEng. = environmental engineering; MgtSci = management science; ME = mechanical engineering.

remained in the program for the first two years of their studies. After the successful completion of the first two years of the program, Scholars were transitioned to an Engineering Fellows Scholarship at the same support level and program activities ceased. Cohort C will complete their second year in the IDEAL Scholars program during the 2013-14 academic year. Each cohort represented approximately 3% of the total size of the first year engineering and computer science class at SMU. The size of the program was intentionally small to allow for community building and the opportunity to pilot programmatic activities.

The program directors aimed to include a diverse group of students in the program. Of the IDEAL Scholars, 21% were non-white, and 46% of the Scholars were female.

Students intending majors in the Lyle School of Engineering at SMU must first meet the subset required for their major. With the exception of two students who left the program, all remaining Scholars successfully declared their intended engineering or computer science major within one academic year. Table 1 summarizes the number of IDEAL Scholars declaring each major.

Term and cumulative GPAs of IDEAL Scholars versus their peers were tracked each semester. On average, IDEAL Scholars term GPAs were 0.510 points higher than their peers and cumulative GPAs were 0.480 points higher than their peers.

At the conclusion of each spring term, IDEAL Scholars completed a summative survey to gain feedback on program components and to gauge their leadership development. Each student completed the survey twice - once at the conclusion of their first year and once at the conclusion of their second year. Students were asked to indicate their favorite and least favorite seminar topics. This information was used to plan seminars for the next academic year. Students were also asked to rate their agreement with statements about programmatic components and their connections to faculty and peers on a scale of 1 (strongly disagree) to 5 (strongly agree). The average student response for the Likert scale questions is shown in Table 2.

Of the program components, the students' reported an increasing view of the helpfulness of the mentoring groups over the years and an increasing view that the program influenced their understanding of leadership. The increasing ratings in these two areas were most likely due to the refinement of mentoring group topics and seminar topics developed over the years. Over all three years, students reported a high degree of satisfaction with the engineering residence community. Students regularly commented that living with other students in their majors was helpful due to the ease in forming study groups and the informal mentoring that occurred among students.

All IDEAL Scholars reported connections to faculty and peers. Program participants consistently reported a high level of connection to engineering/computer science faculty. Additionally, students were connected to peer groups - both inside and outside of the Lyle School of Engineering. Finally, Scholars felt connected to the university.

The summative survey also included questions about IDEAL Scholars' views of leadership and demonstrated leadership skills. Scholars were asked to list three words to describe a leader. Students consistently used words to describe personal characteristics of a good leader rather than titles and management-oriented words. This shows a shift away from an initial view of leaders as people with titles to a view of leaders as people with certain characteristics and behaviors. The average number of organizations and extracurricular activities in which they participated ranged from 4.89 in the 2010-11 academic year to 3.8 in the 2011-12 and 2012-13 academic years. IDEAL Scholars held an average of 1.1 to 1.8 leadership positions in any academic year. To date, IDEAL Scholars have held 19 internships or research experiences with faculty.

TABLE 2
AVERAGE STUDENT RESPONSES TO LIKERT SCALE QUESTIONS ON PROGRAM COMPONENTS.

Statement	Rating from Spring 2011*	Rating from Spring 2012*	Rating from Spring 2013*
Program Components:			
Meeting in small mentoring groups was helpful.	3.56	3.63	4.0
Living in the engineering residence community was a positive experience.	4.67	4.63	4.56
Participating in the IDEAL Scholars program changed my view of leadership.	3.56	3.75	4.33
Connections to faculty and peers			
I feel connected to Lyle engineering.	4.67	4.38	4.56
At least one of my Lyle faculty knows my name.	4.89	4.94	4.94
Compared to my highschool friends at other universities, I have greater access to engineering faculty.	4.44	4.38	4.33
The majority of my friends at SMU are also engineering/CS majors.	4.11	3.81	3.67
In addition to my engineering/CS friends, I have friends in other majors.	4.56	4.31	4.28
I feel connected to SMU.	4.56	4.56	4.67

* Spring 2011 responses were from Cohort A at the end of their first year. Spring 2012 responses were from Cohorts A (at the end of their second year) and Cohort B (at the end of their first year). Spring 2013 responses were from Cohort B (at the end of their second year) and Cohort C (at the end of their first year).

CONCLUSIONS

The IDEAL Scholars program at SMU in the Lyle School of Engineering successfully retained 15 of the 17 students in Cohorts A and B through their second year and is on track to retain all 11 students in Cohort C through matriculation into an engineering/computer science degree program. The program awarded students an annual scholarship and provided curricular and co-curricular activities aimed at building community and fostering leadership development. IDEAL Scholars' term and cumulative GPAs were on average 0.5 points greater than those of their peers. Program components including the weekly seminars, living in the ELLC, and block scheduling were well received by Scholars and helped to build students' connections with faculty, peers and the university. Additionally, the program affected students' view of leadership and many of the students participated in engineering internships. At the conclusion of the 2013-14 academic year, the final cohort of students will complete the program. The program directors are currently working towards institutionalizing aspects of the program and expanding them to a larger population of students.

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AUTHOR INFORMATION

Betsy F. Willis, PhD Director of the Office of Undergraduate Advising and Student Records.

David A. Willis, PhD Associate Professor of Mechanical Engineering

Mark E. Fontenot Lecturer in the Department of Computer Science and Engineering