Long-Term Impact of an Elective, First-Year Engineering Design Course

Ms. W. Jackeline Torres, Rice University

W. Jackeline Torres received her Master of Education and Human Resource Studies from Colorado State University. She is currently a PhD student in the Department of Psychology at Rice University. Her research interests include examining the factors that impact people's achievement in academic and work settings.

Dr. Ann Saterbak, Rice University

Ann Saterbak is Professor in the Practice in the Bioengineering Department and Associate Dean for Undergraduate Education in the School of Engineering at Rice University. Saterbak was responsible for developing the laboratory program in Bioengineering. Saterbak introduced problem-based learning in the School of Engineering and more recently launched a successful first-year engineering design course taught in the Oshman Engineering Design Kitchen. Saterbak is the lead author of the textbook, Bioengineering Fundamentals. Saterbak's outstanding teaching was recognized through university-wide and departmental teaching awards. In 2013, Saterbak received the ASEE Biomedical Engineering Division Theo C. Pilkington Outstanding Educator Award. For her contribution to education within biomedical engineering, she was elected Fellow in the Biomedical Engineering Society and the American Society of Engineering Education.

Dr. Margaret E. Beier, Rice University

Margaret Beier is an Associate Professor of Psychology at Rice University in Houston, TX. She received her B.A. from Colby College, and her M.S. and Ph.D. degrees from the Georgia Institute of Technology. Margaret's research examines the predictors of performance in educational and occupational settings. In particular, she is interested in the effects of examining gender, age, ability, personality, motivation, and self-regulation on a range of outcomes. She is a member of the American Educational Research Association and a Fellow of the Society for Industrial and Organizational Psychologists.

Long-Term Impact of an Elective, First-Year Engineering Design Course

Abstract

This evidence-based practice describes the impact on retention of implementing an elective, first-year engineering design course. Authentic, client-based projects form the focus of a one-semester freshman design course at Rice University. The course is an elective course available for all freshman students in the School of Engineering. During the course, first-year students learn the engineering design process and use it to solve meaningful problems drawn from local hospitals, industry, local community partners, Rice University, and international partners.

The course was designed to meet two high-level objectives in the School of Engineering: (a) to have students learn and practice the engineering design process early in their engineering education, and (b) to increase undergraduate retention in engineering at Rice University by 10 percentage points.

In regards to the first objective, student teams design a product that meets user-defined needs and realistic constraints. Student teams move through the steps of the engineering design process from problem clarification to iterative prototyping. Students communicate with the client and instructors through written reports and oral presentations. Teams are typically composed of four to six students and are expected to work together effectively.

Begun in the spring 2011 with 20 students, the course has been offered every semester since. Course enrollment by academic year is 81 students in 2011-2012, 86 students in 2012-2013, 136 students in 2013-2014, and 125 students in 2014-2015 (total 448). In this study, retention rates in engineering were evaluated for engineer starters who had or had not taken the course.

Students who matriculated in the School of Engineering were considered to be engineer starters if they had earned or attempted at least six STEM credits during their first semester. Credits were determined by summing incoming test score course credit (e.g., AP credit) and attempted course credits in STEM. This resulted in a sample of 867 engineer starters who matriculated in Fall, 2010, Fall, 2011, or Fall, 2012.

Engineering retention was defined as graduating or being on track to graduate with a degree from the School of Engineering. A stratified sample was used to match course enrollees and course non-enrollees on observed characteristics, which were gender, URM status, and academic preparedness. There was an 86% retention rate for engineer starters who had taken the course compared to a 74% engineering retention rate for engineer starters who had not. A chi-square test of independence was performed to examine the relationship between taking the course and obtaining an engineering degree (yes or no). This relationship was significant [$\chi 2(1) = 6.59$, $p = 0.01$]. Engineer starters who took the course were more likely to persist in engineering than engineer starters who did not.

Our aim is to continue to examine the role of engineer starters' early academic experiences, including participation in project-based courses, on retention. Future work will broaden both predictors and outcomes. In particular, we plan to assess engineer starters' attitude toward STEM

(e.g., interest, self-concept, self-efficacy) and academic performance and retention. Future work will include pre-tests and post-tests to control for pre-existing differences in attitude and interest by course enrollment. We will also examine the impact of other early academic experiences on retention, including research experiences and participation in other courses with hands-on learning components.

Introduction

In order to remain competitive in science, technology, engineering, and mathematics (STEM), the U.S. must have a prepared workforce that is ready to address complex problems.[1] The Bureau of Labor Statistics estimated that by the year 2018, there will be approximately three million job openings in STEM, driven in part by emerging jobs and retiring workers.[2] With this need for scientists, the retention of undergraduate engineering students continues to be important. And there is room for improvement; the National Science Foundation reported a 67% retention rate of incoming undergraduate students who declared a science and engineering degree.[3] Another concern is in the comparatively low number of female and URM engineers. Although the percentage of female students who earned an engineering bachelor's degree increased from 17.8% to 19.9% between 2009 and 2014, there are still relatively few women graduating in engineering.[4] A similar situation exists with regards to ethnicity. In 2014, 65.9% of students earning bachelor's degrees in engineering were white, 13.1% Asian-American, 10.1% Hispanic, and only 3.5% Black or African-American students.[4]

Research suggests that attrition is most likely to occur during the first or second year of college for STEM students.[5] Although there are individual factors (e.g., students' ability, interests, academic readiness) that influence decisions to stay or leave engineering, research has also focused on examining the role of students' early academic experiences in a college or university setting on retention.[6] In particular, course quality, class size, availability of instructors, and teaching methods have been shown to be related to attrition.[5,7]

In an effort to improve early academic experiences and increase retention, engineering programs have focused on revamping students' first-year engineering courses to actively engage students in engineering activities. For example, some engineering programs now offer first-year engineering design courses that provide students opportunities to engage hands-on with engineering design.[8,9,10] These courses offer students direct opportunities to practice engineering design, team work, and communication early in their academic career.[11]

Research suggests that engaging students in project-based learning has an array of benefits. In particular, participation in design courses has been shown to increase students' critical thinking,[11] improve academic performance,[12] and increase engineering retention rates.[13,14] Moreover, the benefits of these courses are not limited to one type of student. For example, the engineering retention rate for students who participated in a one-semester engineering design course at the University of Colorado increased for most student groups (i.e., 64% vs 54% for all students, 71% vs 56% for female students, 62% vs 54% for male students, and 64% vs 54% for Caucasian students).[7] The purpose of this study was to examine the effect of participation in an elective engineering design course on retention in engineering specifically and STEM fields more generally.

First-Year Engineering Design Course at Rice University

Introduction to Engineering Design (ENGI 120) is a one-semester multidisciplinary design course for freshman students at Rice University. The course is an elective course available for all freshman students. In ENGI 120, students learn the engineering design process. Teams are formed around student interest in a design project, which the instructors have scoped and pitched. Each team then applies the engineering design process (Figure 1) to solve a challenge drawn from local hospitals, local community partners and non-profits, international communities, and around the Rice University campus. The ENGI 120 course learning outcomes, structure, and deliverables have been described in detail elsewhere.[15]

The first half of the semester is devoted to the following steps: restating the design problem, conducting background research to understand the problem and its context, establishing design criteria, brainstorming solutions, using a Pugh matrix to evaluate and select a solution, and then describing the selected solution in more detail. During the second half of the semester, student teams focus on physical prototype development and testing in the Oshman Engineering Design Kitchen (OEDK). The OEDK maintains hand tools, prototyping supplies, and several pieces of advanced manufacturing equipment for student design teams to use.

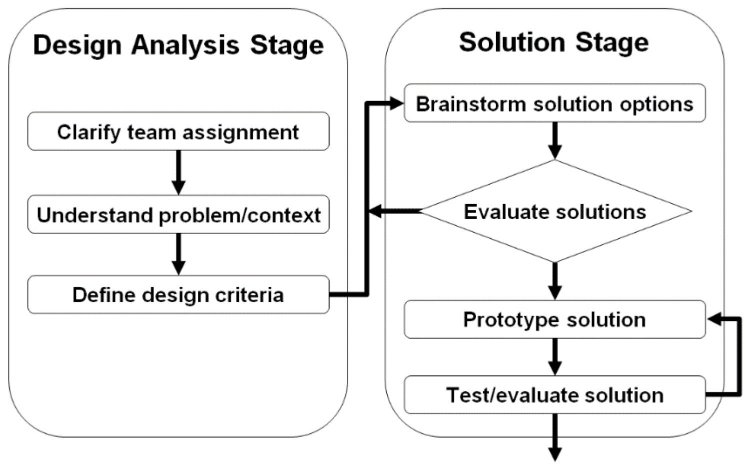

Figure 1. Engineering design process

The course was offered for the first time in Spring, 2011 with 20 enrolled students. ENGI 120 has been offered every semester since. Course enrollment by academic year is shown in Table 1.

Table 1. First-year Engineering Design Course Enrollment

Academic Year	**Course Enrollment**
Spring 2011	20
Fall 2011-Spring 2012	81
Fall 2012-Spring 2013	86
Fall 2013-Spring 2014	136
Fall 2014-Spring 2015	125
Total	**448**

Research Methods

Identifying Engineer Starters

While students indicate a 'preference' for division/major area of study when applying to Rice University, admission is not into a school or department. Students are able to move freely throughout the university until they declare their major during the fourth semester and tracking students within a school and department has always been a vexing problem at Rice University. Thus, matriculating students who nominally enter in the School of Engineering because they had indicated that preference when they applied to college during the spring before matriculation, may not actually intend to pursue an engineering degree when they arrive on campus. Thus, our first task was to identify engineer starters so we could more cleanly assess retention in engineering. For this purpose, we used archival student data to identify students' course choices at matriculation. Students who matriculated in the School of Engineering and actively engaged in STEM courses are likely to be engineering students and hence were labeled as "engineer starters." Students who attempted or earned at least six STEM credits were categorized as "engineer starters." STEM credits were determined by summing incoming test score course credit (e.g., AP credit) in STEM and course enrollment in STEM (e.g., math, chemistry, physics courses). Enrollment data was checked immediately after the final add deadline (end of the second week of school). Note that this method captures students who took and failed STEM courses as well as students who started but dropped STEM courses. Thus, we are not biasing our sample only toward students who are successful along a STEM pathway. Students who indicated an admission preference for engineering but made no effort to enroll in STEM courses in their first semester and/or did not have some AP credit in STEM courses from high school were not considered engineer starters. This is consistent with the reality that all engineering programs require completion of six or more STEM hours credit by the end of the first semester to stay on track to graduate within four years.

This algorithm resulted in a total of 867 engineer starters who matriculated in Fall, 2010 (n = 303), Fall, 2011 (n = 290), and Fall, 2012 (n = 274). Note that this number does not include engineer starters who failed to graduate and also have no course enrollment (e.g., due to medical leave, academic probation, or left university) in this analysis (n = 76). Most Fall, 2010 and Fall, 2011 matriculants have graduated, permitting us to examine persistence as an outcome. By contrast, most of the Fall, 2012 cohort are still enrolled, which is expected given that four years is typical to complete an engineering degree. For enrolled students, we assumed they were persisting in an engineering major if they were enrolled in senior-level engineering courses. In summary, a student was counted as persisting in engineering (our outcome of interest) if he or she graduated with a degree in engineering or was engaged in a senior-level design course.

Overall, 35% of the engineer starters in this study were women and 20% were under-represented minority (URM) students, which included African American, Hispanic, Pacific Islander, and Native American students (see Table 2). Furthermore, 136 students (16%) completed ENGI 120, which mainly consisted of engineer starters who matriculated in Fall, 2011 (n = 63) and Fall, 2012 (n = 56), with a smaller group who matriculated in Fall, 2010 (n = 17).

Table 2. Catalogue of Engineer Starters

		Fall 2010	Fall 2011	Fall 2012	Combined Fall 2010, Fall 2011, and Fall 2012
Overall Cohort		303	290	274	867
Gender					
	Male	214	176	175	**65%** (565)
	Female	89	114	99	**35%** (302)
URM	Total	47	63	65	**20%** (175)
	Male URM	25	39	40	**12%** (104)
	Female URM	22	24	25	**8%** (71)
Student Status					
	Graduates	295	275	16	586
	Enrollees	8	15	258	281
ENGI 120 Completion		17	63	56	136

Notes:
Graduates: status refers to engineer starters that have graduated as of May 2015.
Enrollees: status refers to engineer starters that were enrolled in courses in Fall 2015.

Characteristics of Course Enrollees and Non-Enrollees

We wanted to understand the degree of any pre-existing difference between engineer starter who elected to take ENGI 120 and engineer starters who did not. There were no differences between engineer starters who took ENGI 120 and engineer starters who did not take ENGI 120 in terms of gender [$t(865) = 1.10$, $p = 0.27$] or URM status, [$t(180.05) = 1.22$, $p = 0.22$)]. Incoming test score course credits, specifically AP credits, were used as an index of academic preparedness; we did not have access to high school GPA or ACT/SAT results. Engineer starters in this study had a mean of 25.4 test score course credits ($SD = 15.7$ credits), with a median of 26 credits and a 25th percentile of 14 credits. There was no statistically significant difference of earned test score course credits between women ($M = 25.2$, $SD = 15.4$) and men ($M = 25.4$, $SD = 15.9$) [$t(865) = 0.18$, $p = 0.86$). However, there was a statistically significant difference in earned test score course credits between engineer starters who elected to take ENGI 120 ($M = 28.51$, $SD = 15.38$) and engineer starters who did not ($M = 24.77$, $SD = 15.75$) [$t(865) = 2.55$, $p = 0.01$). ENGI 120 consisted of 59% engineer starters with incoming test credits at or above the median of 26 credits and 41% of engineer starters with incoming test credits below the median of 26 credits. In other words, the class was slightly enriched with students with more AP credits, which makes sense given that students must find room in a packed first-year schedule for this course. In a later section, we examine the relationship between enrollment in ENGI 120 and persistence in engineering for engineer starters by taking into account incoming test score course credits.

Classification of Engineer Starters by Outcome

We classified engineer starters into one of six outcome groups according to data obtained in student degree records. Engineering Graduates were engineer starters who graduated in engineering as of May, 2015. Engineering Enrollees were considered to be on track to graduate with a degree from the School of Engineering if they were enrolled in mandatory senior-level engineering design courses during Fall, 2015. Additional possible outcomes for engineer starters include earning a degree in natural science (STM Graduates and Enrollees), or outside of engineering and natural science (Non-STEM Graduates and Enrollees). Each engineer starter was classified into one of six groups based on the outcome they achieved, as listed and defined in Table 3. Table 4 shows the percentages of each outcome group in the sample.

Table 3. Classification of Engineer Starters

Outcome	**Definition**
Engineering Graduates	Graduated engineer starters who earned a degree from the School of Engineering
Engineering Enrollees	Enrolled engineer starters who are on track to graduate with a degree from the School of Engineering
STM	Acronym used to describe STEM field with the engineers removed; Science or mathematics
STM Graduates	Graduated engineer starters who earned a STM degree
STM Enrollees	Enrolled engineer starters who are on track to graduate with a STM degree
Non-STEM Graduates	Graduated engineer starters who earned a non-STEM degree
Non-STEM Enrollees	Enrolled engineer starters who are on track to graduate with a non-STEM degree
Notes: **STM degree:** earned degree awarded in the School of Natural Science, which includes physical and biological sciences and mathematics. **Non-STEM degree:** earned a degree not in science, technology, engineering or mathematics (STEM).	

Table 4. Classification of Engineer Starters by Outcome

Outcome	Fall 2010	Fall 2011	Fall 2012	Combined Fall 2010, Fall 2011, and Fall 2012
ENGI Graduates and ENGI Enrollees	250	236	217	**81%** (703)
STM Graduates and STM Enrollees	24	24	24	**8%** (72)
Non-STEM Graduates and Non-STEM Enrollees	29	30	33	**11%** (92)
Total	303	290	274	867
Notes: Cells represent number of engineer starters in each category.				

Research Design, Statistical Tests, and Package Used

We used a quasi-experimental field study design, since it was not feasible to randomly assign engineer starters to design course conditions. When analyzing the data, we used two different approaches. First, we analyzed all engineer starters and tracked whether they were retained in engineering or not. Second, we analyzed the data using a stratified sample on variables that could be related to engineer starters electing to enroll or not enroll in the course. For both cases, causal inferences cannot be drawn from the results. In the statistical analysis that follows, the relationship between engineering and STEM retention and completion of ENGI 120 was examined through chi-square of independence tests. The Statistical Package for the Social Sciences (23) was used to run these statistical tests.[16]

Results

Engineering Retention – Analyzed Using All Engineer Starters

To assess the effects of a first-year engineering design course, engineering retention was considered for all engineer starters who matriculated in Fall, 2010, Fall, 2011 or Fall, 2012 and were still enrolled at Rice University or had graduated. Engineering retention was defined as engineer starters who were classified as engineering graduates or engineering enrollees (see Table 3 for outcome definitions). Collapsed across all three matriculation years, engineering students had an overall 81% engineering retention rate (Table 5). For engineer starters who do not stay in engineering, 8% are STM field graduates or enrollees, whereas 11% are non-STEM graduates or enrollees (Table 4).

As shown in Table 5, engineer starters who completed ENGI 120 had an 86% engineering retention rate as compared to an 80% engineering retention rate for those who did not complete the course. The retention rate was higher for most student groups enrolled in the design course compared to no course enrollment (i.e., 92% vs. 84% for male students, 77% vs 73% for female students, 88% vs 82% for non-URM students, and 79% vs 74% for URM students). However, the difference in the retention rate was only statistically significant for male students [$\chi2(1)$ =

3.47, $p = 0.06$] and non-URM students at the $p < 0.10$ level [$\chi 2(1) = 2.73$, $p = 0.098$]. It is notable that there are fewer than 200 URM students in total in the sample over a three year matriculation span; the retention rates for URM students are not split by gender due to small sample sizes in each cell.

Table 5. Engineering Retention Rate of All Engineer Starters

Group	**Engineering Retention Rate**
All	**81%** (703/867)
ENGI 120	**86%** (117/136)
No ENGI 120	**80%** (586/731)
Males	**85%** (479/565)
ENGI 120	**92%** (76/83) *
No ENGI 120	**84%** (403/482) *
Females	**74%** (224/302)
ENGI 120	**77%** (41/53)
No ENGI 120	**73%** (183/249)
Non-URM	**83%** (572/692)
ENGI 120	**88%** (91/103) *
NO ENGI 120	**82%** (481/589) *
URM	**75%** (131/175)
ENGI 120	**79%** (26/33)
NO ENGI 120	**74%** (105/142)

Notes:
Chi-square tests of independence were performed to examine relationship between taking the design course and engineering retention, relationships are significant at the * $p < 0.1$ level.
Parentheses: includes the number of graduated or enrolled engineer starters persisting in Engineering divided by engineer starters.

Engineering Retention – Analyzed Using Stratified Sample of Engineer Starters

Selection bias may be present in that engineer starters who elected to enroll in ENGI 120 may have differed in important ways from engineer starters who did not enroll in ENGI 120. This current analysis used a stratified sample technique to match course enrollees (n = 136) to a randomly selected group of course non-enrollees (n = 136) on variables that could be related to electing to enroll or not enroll in the course, which were gender (i.e., male or female), URM status (i.e., URM student or non-URM student), and academic preparedness (i.e., above or below the median of 26 test score course credits). Table 6 shows the percentage of engineer starters retained in engineering by course enrollment using the stratified control group. The overall engineering retention rate of this sample was 80%. Retention rates for engineer starters who had taken ENGI 120 was 86% compared to a retention rate of 74% for engineer starters who had not taken the course. A chi-square test of independence was performed to examine the relationship between taking the course and engineering retention. This relationship was significant [$\chi 2(1) = 6.59$, $p = 0.01$]. Engineer starters who enrolled in the course were more likely to persist in engineering than engineer starters who did not enroll in the course.

Table 6. Engineering Retention Rate of Stratified Sample of Engineer Starters

	Engineering Retention Rate			
	No	**Yes**		**Total**
ENGI 120 Non-Enrollees	36 (27%)	100 (74%)	**	136
ENGI 120 Enrollees	19 (14%)	117 (86%)		136
Total	55 (20%)	217 (80%)		272

Notes:
Chi-square test of independence was performed to examine relationship between taking the design course and engineering retention, relationship is significant at the **$p < 0.05$ level.

ENGI 120 non-enrollees refers to a stratified random sample of engineer starters who did not enroll in ENGI 120. ENGI 120 enrollees are actual engineer starters who took ENGI 120. Engineering retention was defined as engineer starters who were classified as Engineering Graduates or Engineering Enrollees (see Table 3 for outcome definitions).

STEM Retention – Analyzed Using Stratified Sample of Engineer Starters

Outcome analysis was extended by also considering STEM retention, defined as engineer starters who graduated or are on track to graduate with a degree from either the School of Engineering and/or a STM degree (e.g., math, biology, chemistry, etc.). The overall STEM retention rate using the stratified sample was 89%, which breaks down to 86% for those who did not complete

ENGI 120 and 92% those who did complete the course (data not shown). The difference in STEM retention rates was not significant [$\chi2(1) = 2.40$, $p = 0.12$].

Discussion and Future Directions

The aim of this study was to examine the impact of a first-year engineering design course on engineering retention. The overall observed engineering retention rate of all engineer starters in this study's sample was 81%, which is high compared to the national retention rate estimate of 67%.[3] Engineer starters who completed an introductory engineering design course had higher engineering retention rates compared to those who did not, including for male students, female students, non-URM students, and URM students. However, these retention-rate differences were statistically significant only for male engineer starters and non-URM engineer starters. A stratified sample based on gender, URM status, and academic preparedness showed that there was a statistically significant relationship between ENGI 120 enrollment and engineering persistence, such that engineer starters who participated in the course had higher persistence rates than engineer starters who did not.

Because ENGI 120 is an elective course, it may be that engineer starters who enroll are more likely to persist in engineering because they are more interested in the topic than those who do not enroll. Because the archival data examined here did not include assessment of student interest in engineering or STEM before course enrollment, we cannot rule out this possibility, or the possibility that other individual differences at the start of the undergraduate career influenced course enrollment. From conversation with students, we have a general sense that many students who take the course tend to be committed to engineering. However, we also know that other students who want to learn more about the field of engineering and/or who are unsure if they will like engineering also take the course. Although students learn about the course at freshmen orientation and are encouraged to participate in the course by their academic advisors, students with few incoming test score course credits (e.g., AP test credits) may struggle to fit the course into their course schedules. This is borne out by the slight over-enrichment of students with AP credits above the median. Overall, most students taking the course will be those who are oriented toward engineering. We did not examine the relationship between interest in engineering, course engagement, and persistence in engineering; this is a topic for future research.

The results of this current study imply that early engagement in the engineering process is beneficial for the retention of engineer starters. However, we acknowledge that one course may not be sufficient when faced with other challenges, such as demanding first-year mathematics or physics courses or second-year engineering fundamentals courses, when selecting an engineering major. Academic programs should continue to focus on providing holistic academic support (e.g., mentoring, tutoring) towards student achievement in engineering.

This study is a first step in a research program that will include examining the impact of project-based instruction on academic persistence and performance. Future work includes the addition of new cohorts to our engineer starter sample to increase the sample size and to examine engineer retention over time with different subgroups; larger samples will enable us to provide more stable estimates for the effect of ENGI 120 on retention based on gender and URM status. Moreover, we aim to broaden both the predictors and outcomes examined in this work. In particular, we plan to assess student attitudes toward STEM fields (e.g., interest, self-concept, self-efficacy), and relative changes in these attitudes based on enrollment in ENGI 120. Because we cannot randomly assign students to courses, future research will also employ a quasi-experimental design, but care will be taken to use a pre-test/post-test approach to enable us to control for any pre-existing differences in student interest and attitudes by course enrollment. Additional planned research will expand the project-based courses examined to include other early academic experiences, including research experience and participation in other courses with an array of different active learning components.

Acknowledgments

This work was supported in part by a grant to Rice University from the Howard Hughes Medical Institute through the Precollege and Undergraduate Science Education Program

References

[1] X. Chen and M. Soldner, “STEM Attrition: College Students’ Paths into and out of STEM Fields. Statistical Analysis Report. NCES 2014-001.,” *National Center for Education Statistics*, 2013.

[2] T.A. Lacey and B. Wright, B, “Occupational employment projections to 2018,” *Monthly Labor Review*, vol. 132, no. 11, pp. 82 – 123, 2009.

[3] National Science Foundation [NSF], “What is the S&E retention rate in U.S. 4-year institutions?” [Online]. Available: https://www.nsf.gov/nsb/sei/edTool/data/college-10.html [Jan. 23, 2016].

[4] B. L. Yoder, “Engineering by the Numbers,” American Society for Engineering Education, Washington, DC, 2014.

[5] E. Seymour and N. M. Hewitt, *Talking About Leaving: Why Undergraduates Leave the Sciences*, Boulder, CO: Westview Press, 1997.

[6] S. Olson and D. G. Riordan, “Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics. Report to the President.,” *Executive Office of the President*, 2012.

[7] D. W. Knight, L. E. Carlson, and J. F. Sullivan, “Staying in engineering: Impact of a hands-on, team-based, first-year projects course on student retention,” in *CD) Proceedings, ASEE Conference and Exhibition*, 2003.

[8] University of Maryland, "Keystone – Engineering the Future" [Online]. Available: http://www.keystone.umd.edu/home.

[9] Ohio State University, "First-Year Engineering Program" [Online]. Available: https://eed.osu.edu/first-year-engineering-program.

[10] Michigan State University, “Cornerstone and Residential Experience” [Online]. Available: http://www.egr.msu.edu/core/

[11] R. M. Marra, B. Palmer, and T. A. Litzinger, “The effects of a first-year engineering design course on student intellectual development as measured by the Perry scheme,” *Journal of Engineering Education*, vol. 89, no. 1, pp. 39–46, 2000.

[12] R. Parsons, C. Pionke, and E. Seat, “The Engage Program: First-Year Team Design to Complement an Integrated Curriculum,” in *Proceedings of the 2002 International Conference on Engineering Education, Manchester, UK. August 2002*, 2002.

[13] Richardson, J.; Dantzler, J., "Effect of a freshman engineering program on retention and academic performance," in *Frontiers in Education, 2002.*

[14] C. Pomalaza-Ráez and B. H. Groff, “Retention 101: Where robots go… students follow,” *Journal of Engineering Education*, vol. 92, no. 1, pp. 85–90, 2003.

[15] A. Saterbak, M. Embree and M. Oden, "Client-based projects in freshman design," in *American Society of Engineering Education Conference Proceedings*, San Antonio, 2012.
[16] IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.