International Journal of Engineering Education Vol. 32, No. 5(A), pp. 1879–1887, 2016
Printed in Great Britain
0949-149X/91 $3.00+0.00

Factors Affecting Persistence of Undergraduate Engineering Students: A Quantitative Research Study Using Institutional Data*

MATTHEW MEYER and NING FANG**
Department of Engineering Education, College of Engineering, Utah State University, Logan, UT 84322, USA.
E-mail: ning.fang@usu.edu

Persistence of undergraduate engineering students has long been a challenging issue in many engineering programs at higher education institutions in the United States (U.S.). Although much research has been performed to study factors affecting student persistence, research findings vary from institution to institution due to cultural and other unique differences at each institution. The present research adds to the knowledge base by employing readily available institutional data to determine factors affecting persistence of engineering undergraduates at a public research university in the U.S. Institutional data collected on declared engineering majors were sorted into equal-sized groups of 383 persisting students and 383 non-persisting students, totaling 766 students. Statistical t-tests were performed to analyze numerical (continuous) data that correspond to four factors: high school GPA (graduate point average), ACT (American College Testing) math score, composite ACT score, and projected age at graduation. Statistical Pearson's chi-squared tests were conducted to analyze categorical data that correspond to six other factors: gender, marital status, residency status, campus residence, scholarship, and financial aid. The results of statistical analysis show that students with higher high school GPAs, ACT math scores, or composite ACT scores were more likely to persist in engineering. Older or married students were also more likely to persist than younger or single students. When compared with in-state resident students, out-of-state resident students were less likely to persist, and international students were more likely to persist. Students who had received financial aid were more likely to persist than those who did not. These research findings have practical implications. Higher education institutions can adjust entrance criteria to increase the chances of success for students admitted into engineering programs.

Keywords: persistence; undergraduate engineering students; institutional data; quantitative research

1. Background introduction

1.1 Persistence of science, technology, engineering, and mathematics (STEM) undergraduates in the United States

The United States (U.S.) is losing its long-held superiority in technological innovation. A number of measures indicate the weakening of the engineering profession in relation to developing countries such as China, India, and Russia [1, 2]. In 2009, for the first time, more than half of U.S. patents were awarded to non-U.S. companies and China replaced the U.S. as the number one exporter of technology [3].

Many point to the failings of the U.S. educational system as the primary reason for this disturbing trend [4, 5]. In 2011, the World Economic Forum ranked the U.S. as 48th out of 133 countries in the quality of math and science instruction [3]. Although millions of dollars have been invested to grow interest in science, technology, engineering, and mathematics (STEM) for high school, middle school, and even elementary school students, the decline of engineering graduates, compared to some developing countries, continues. Many capable students avoid STEM education or drop out of STEM programs in college. Seymour and Hewitt [6] reported that 44.1% of STEM majors switched to non-STEM majors before graduation.

In March 2006, a hearing was held before the subcommittee on research in the U.S. House of Representatives concerning best practices in undergraduate math, science, and engineering education [7]. Five experts in the field of undergraduate education relayed their experience with a critical problem facing STEM educators: persistence of qualified students. In his testimony before the U.S. House Subcommittee on Research [7], Dr. Carl Wieman, a distinguished physicist and educator, testified, "Science majors are not being created in college. Rather, they are primarily the few students that, because of some unusual predisposition rather than ability, manage to survive their undergraduate science instruction," and "Unless we improve STEM education at the college level first, we are wasting our time and money on making major improvements in K-12." Dr. Wieman further argued that engineering education at the university

** Corresponding author.

* Accepted 18 May 2016.

level was "based on an outdated model" and required a major overhaul before it could accommodate increased interest in engineering education [7].

1.2 Research on persistence in STEM education

To stem the decline of STEM (particularly engineering) in the U.S., much effort has been made to improve the number and diversity of STEM graduates [8]. Relevant research has also been conducted, focusing on STEM career preparation [9, 10] and persistence of undergraduate students in general and STEM undergraduates in particular [11–13]. The research methods employed in these persistence studies involved quantitative, qualitative, or mixed-methodological forms of inquiry [14].

These persistence studies have been useful in determining what factors lead to persistence or non-persistence in STEM programs, determining rates of attrition, and assessing intervention strategies to improve persistence [15]. The most prevalent reasons cited in the literature for low-persistence rates of STEM majors include lack of K-12 preparation for the rigor of STEM education, poor teaching and counseling, and students' difficulty adapting to the educational and social demands of STEM programs [16–19].

In addition, research shows that gender, race, ethnicity, and employment are relatively less significant factors in affecting persistence [20, 21]. Qualitative studies have attempted to show a relationship between the culture of various universities and their effect on persistence of engineering undergraduates [22]. These studies have shown dissatisfaction with many aspects of undergraduate engineering education. Students have criticized faculty for poor teaching and mentoring, and for creating an ultra-competitive, weed-out culture [6]. Engineering faculty has criticized students for lack of commitment, poor preparation, lack of focus, and poor study habits [21]. Employers have criticized both engineering faculty and students for the lack of preparation exhibited by engineering graduates in the workforce [23–25].

On the other hand, Herzog [26] argued that determining why students drop out is less important than being able to predict why students transfer out. Relevant research has been conducted to determine what factors or characteristics are predictive of success in completing undergraduate engineering programs [16, 19, 27–30]. However, the results of these studies have been mixed. It has been reported that SAT (Scholastic Assessment Test) and ACT (American College Testing) test scores are indicative of students' success. The SAT and ACT are two major college readiness assessment tests widely used for college admission in the U.S. Students with higher scores, especially in the mathematics sections of these standardized tests, have been shown to persist in engineering programs at a higher rate than students with lower test scores [6]. Similar relationships have been shown for students with higher grades in high school, although this relationship is harder to define with widely varying instruction and grading structures in the high schools from which these students are drawn [31]. Based on statistical data from nine institutions across the U.S., Zhang, Anderson, Ohland, and Thorndyke [32] found that math SAT scores and verbal SAT scores have opposite effects on graduation rates of engineering students. The graduation rates were positively correlated with math SAT scores but negatively correlated with verbal SAT scores.

1.3 The scope of the present study

Although much research has been performed to study factors affecting persistence for STEM majors in general and engineering majors in particular, research findings vary from institution to institution due to cultural and other unique differences in each institution. The present research adds to the knowledge base by employing readily available institutional data (such as student demographics, academic performance measures, socioeconomic status, and residence) to determine factors affecting persistence of engineering undergraduates at Utah State University (USU), a public research university in the U.S.

The scope of the present research is restricted to readily available institutional data for determining the factors affecting student persistence. The reason for using institutional data for this research is that nearly all institutions across the country have maintained institutional data; therefore, the quantitative research method employed in the present study can be easily adopted by all institutions. The factors that are not typically represented in institutional data, such as student personality, self-regulated learning skills, and the time students spend in their academic studies, as well as the quality of teaching, mentoring and advising, are not considered in the present study. In addition, the present study does not aim to study why students drop out of engineering. The latter research is a relevant but different qualitative study and requires separate papers to address.

2. Research question and method

2.1 Research question

The institutional data collected at USU include students' high school GPA (graduate point average), ACT math score, composite ACT score, gender, residency status, race/ethnicity, religion, campus residence, scholarship, and so on. Only representative factors are considered in the present study, and the factors that are unique at USU only are excluded. For example, the vast majority of undergraduate engineering students at USU are white students and are also members of the Church of Jesus Christ of Latter-day Saints. Therefore, the present study does not involve race/ethnicity and religion because these two factors are quite unique at USU and do not represent the majority of higher learning institutions nationwide.

The research question of the present study is, therefore, as follows: Based on the institutional data collected at Utah State University (a public research university in the U.S.), which of the following 10 factors are associated with persistence of undergraduate engineering students?

1. High school GPA.
2. ACT math score.
3. Composite ACT score.
4. Projected age at graduation.
5. Gender.
6. Marital status.
7. Residency status.
8. Campus residence.
9. Scholarship.
10. Financial aid.

Table 1 summarizes the above 10 factors as well as 10 research sub-questions that each corresponds to an individual factor. To avoid ambiguity, these 10 factors are explained and highlighted in italics in the following paragraphs.

High school GPA (Grade Point Average), reported numerically with a range of 0–4, is the major indication of a student's academic performance in high school. The data on student academic performance (e.g., final grades) on college courses is limited and incomplete in the institutional data at USU, which makes it difficult to use to draw any meaningful comparisons between persisters and non-persisters. Therefore, students' college performance was not investigated in the present study.

The ACT (American College Testing) has four subject areas: English, math, reading, and science. The *ACT math score* is the score a student earned in the subject area of math. The *composite ACT score* is the average of a student's English, math, reading, and science scores. Both the ACT math score and the composite ACT score have a numerical range of 0–36.

The institutional data at USU contains each student's birthdate and a date of expected graduation. Comparing the two dates enabled determination of each student's *projected age at graduation*. The institutional data also contains each student's *gender* as either male or female. A student's *marital status* was reported as married, single, or divorced.

Students at USU pay their tuition based on three *residence statuses*: in-state resident, out-of-state resident, and international student. In-state residents pay less than out-of-state residents and international students. Regarding *campus residence*, the institutional data contains the information whether a student had ever lived in the university's on-campus housing, or had never lived in on-campus housing.

Some students receive merit-based *scholarships* from the university to financially support their undergraduate study. Some students receive

Table 1. Summary of results for 10 factors analyzed for student persistence

Factors	Research sub-questions	Analysis technique employed	Is there statistically significant difference in the group means? $P = 0.05$
High school GPA	Are students with higher high school GPA more likely to persist?	*t*-test (2-tailed)	Yes
ACT math score	Are students with higher ACT math scores more likely to persist?	*t*-test (2-tailed)	Yes
Composite ACT score	Are students with higher composite ACT scores more likely to persist?	*t*-test (2-tailed)	Yes
Projected age at graduation	Are older students more likely to persist?	*t*-test (2-tailed)	Yes
Gender	Are female students less likely to persist?	Pearson's chi-squared test	No
Marital status	Are married students more likely to persist?	Pearson's chi-squared test	Yes
Residency status	Are Utah residency, nonresidency, or international residency factors in student attrition?	Pearson's chi-squared test	Yes
Campus residence	Are students who lived on campus more likely to persist?	Pearson's chi-squared test	No
Scholarship	Are students with scholarships more likely to persist?	Pearson's chi-squared test	No
Financial aid	Are students with financial aid more likely to persist?	Pearson's chi-squared test	Yes

needs-based *financial aid* from federal government programs such as Free Application for Federal Student Aid (FAFSA) and Federal Pell Grants.

2.2 Overall research method

In the present study, quantitative research involving statistical analysis of institutional data was conducted to answer the research question stated in the Introduction section. After the present study was approved by the Institutional Review Board at USU, relevant institutional data were extracted from the university's Banner system, which is an administrative software system developed specifically for higher education institutions [33] and which contains financial and personnel data of students and alumni. A popular computer software program for predictive analytics called Statistical Package for the Social Sciences (SPSS), version 21.0 [34], was then employed to process institutional data collected from Banner and other supplemental resources.

In Section 3.1, we further describe the university site (i.e., USU) at which the present study was conducted, student participants in terms of non-persisters and persisters, and data collection. In section 3.2, we describe the detailed method of statistical data analysis.

3. Data collection and method of statistical data analysis

3.1 Data collection

With a STEM-dominant Carnegie classification, Utah State University (USU) offers BS, MS, and PhD degrees in mechanical, civil, environmental, electrical, computer, and biological engineering. These engineering programs are accredited by the Accreditation Board for Engineering and Technology (ABET) [35]. Particularly relevant to the present study, these engineering degrees have a pre-professional and professional course of study. The pre-professional program constitutes freshman and sophomore years, and the professional program includes junior and senior years. Entry into each engineering discipline's professional program is predicated on a student's performance in the pre-professional program. After three failing course grades in the pre-professional program, a student is not allowed to enter into the professional program.

The student participants involved in the present study were declared engineering majors at USU from academic year 2006–2007 through 2012–2013. For statistical comparison purposes, these students were divided into two groups: non-persisters and persisters. In the present study, these two groups of students are defined and selected as follows.

Non-persisters are defined as students who transferred out of engineering. Since 2011, the USU College of Engineering maintains a list of non-persisting undergraduate students. From January 1, 2011, through February 26, 2014, there were 383 students who requested to transfer out of an engineering major at USU. Data on the destination of these students who left engineering were not collected. None of these students had been accepted into a professional engineering program. These 383 students comprised the group analyzed as non-persisters. The group of non-persisters was chosen because they had identified themselves as non-persisting students by signing the engineering college's list as they left engineering.

Persisters are defined as students who had successfully completed a 3000-level (i.e., junior year-level) engineering course. The USU College of Engineering does not allow students to take a 3000-level engineering course without acceptance into one of the professional engineering programs. In other words, persisters are students who had successfully entered into an engineering professional program. USU has records of all students who had taken a 3000-level engineering course from academic year 2006–2007 through 2012–2013. During this time period, 2,088 students had successfully completed a 3000-level engineering course.

In an effort to match the number of persisting students and the number of non-persisting students over similar timeframes, the latest expected graduation dates were used to narrow the list of persisters. Of the 2,088 students who had successfully completed a 3000-level engineering course, the 383 with the latest expected graduation dates were purposely selected for analysis in the present study. This method of selecting persisters has an added benefit of using students whose records were newer and more complete than those persisters who had taken a 3000-level course in 2005 or 2006. Data collected during these years may not have adequately been transferred to Banner, or the data may have been collected in a different manner. Thus, comparisons of non-Banner data with Banner data were discouraged due to possible inconsistency.

After the list of 766 students, comprising 383 persisters and 383 non-persisters, had been compiled, a request was made to the registrar's office at USU to provide data for each of these students from the university's Banner record-keeping system. It should be noted that at no time did the researchers have access to any personal identifying data on the students. The engineering college coded identifiers of non-persisting students, and has not shared the key with the researchers.

3.2 Statistical analysis of the institutional data

Descriptive and inferential statistics were performed to compare the persisting group with the non-persisting group. Depending on the type of data (numerical or categorical), statistical analysis through either *t*-tests or Pearson's chi-squared tests [36] was conducted to determine if there exists a statistically significant difference in any factor between the persisting group and the non-persisting group.

As shown in Table 1, 2-tailed independent *t*-tests were conducted on numerical (i.e., continuous) data including high school GPA, ACT math score, composite ACT score, and projected age of graduation. Statistically significant differences are reported using *p*-values at 0.05, a common standard for significance determination [36]. Pearson's chi-squared tests were performed on categorical data including gender, marital status, residency status, campus residence, scholarship recipient, and financial aid. Statistically significant differences are also reported using p-values at 0.05 [36].

4. Results and analysis

4.1 Significance of high school GPA on persistence

Table 2 summarizes the results of *t*-tests. The number of persisting and non-persisting students varies from factor to factor, depending on the availability of institutional data associated with each individual student. The institutional data contained a high school GPA for 529 students out of the 766 students involved in the present study. Based on the results of *t*-tests shown in Table 2, although the mean scores of high school GPA for persisters and non-presisters seem close (3.67 vs. 3.58), the difference between the mean scores for persisters and non-presisters is statistically significant ($p = 0.012$) due to the sample size. This result affirms that statistically, students with higher high school GPAs were more likely to persist in engineering.

4.2 Significance of ACT math and composite ACT scores on persistence

Most students took the ACT test to gain admission into USU. The results shown in Table 2 indicate that there exist statistically significant differences in ACT math scores ($p = 0.001$) and in composite ACT scores ($p = 0.001$) between persisters and non-presisters. The mean score of ACT math for persisters is higher than that for non-persisters (27.32 vs. 26.09). The mean score of composite ACT for persisters is also higher than that for non-persisters (26.14 vs. 25.10). These data suggest that the requirements for incoming freshmen are already lofty. The engineering college faces the often competing priorities of student recruiting and persistence. Raising the minimum ACT test score requirement for incoming freshmen may increase persistence of those students who can still make it into the professional program.

4.3 Significance of projected age at graduation on persistence

The institutional data contained students' birthdates and dates of expected graduation for all 766 students involved in the present study. This enabled the determination of each student's projected age at graduation. As shown in Table 2, the mean projected age at graduation for persisters (28.58) is significantly higher than that for non-persisters (25.57). This age difference is statistically significant ($p = 0.001$), implying that older students are much more likely to persist than younger students. A reasonable explanation is that older students are more likely to have developed a better understanding of the engineering profession and to have more mature study habits and learning skills.

4.4 Significance of gender on persistence

Table 3 summarizes the results of Pearson's chi-squared tests. Among 766 student participants, 682 were males and 84 were females. As seen from Table 3, males persisted at a higher percentage than did females: 50.7% vs. 44.0%. However, there exists no statistically significant difference in gender between persisters and non-persisters ($p = 0.248$). In other words, although female students at USU are in the minority, gender does not play a significant role in engineering student persistence. The USU engineering program has made an effort to recruit and retain female students through female-focused groups and activities. The results of the present study show that these efforts were successful from a perspective of

Table 2. Summary of results of *t*-tests

Factors	**Mean score of persisters**	**Mean score of non-persisters**	***P*-values from *t*-tests**	**Is there statistically significant difference in the group means? *P* = 0.05**
High school GPA	3.67 (N = 208)	3.58 (N = 321)	0.012	Yes
ACT math score	27.32 (N = 231)	26.09 (N = 324)	0.001	Yes
Composite ACT score	26.14 (N = 233)	25.10 (N = 324)	0.001	Yes
Projected age at graduation	28.58 (N = 383)	25.57 (N = 383)	0.000	Yes

Table 3. Summary of results of Pearson's chi-squared tests

Factors	Categories	Percentage of persisters	*P*-values from Pearson chi-square tests	Is there statistically significant difference in the group means? *P* = 0.05
Gender	Male (N = 682)	50.7	0.248	No
	Female (N = 84)	44.0		
Marital status	Single (N = 493)	45.0	0.000	Yes
	Married (N = 217)	61.8		
Residency status	In-state resident (N = 658)	50.0	0.001	Yes
	Out-of-state resident (N = 65)	35.4		
	International student (N = 43)	72.1		
Campus residence	Lived on campus (N = 223)	50.2	0.937	No
	Did not live on campus (N = 543)	49.9		
Scholarship	Received scholarship (N = 303)	48.2	0.416	No
	Did not receive scholarship (N = 463)	51.2		
Financial aid	Received financial aid (N = 419)	61.6	0.000	Yes
	Did not receive financial aid (N = 347)	36.0		

student persistence but not necessarily in equalizing the number of males and females in the program.

4.5 Significance of marital status on persistence

In terms of marital status, the majority of students (493) were single, and 217 students were married. Only three students reported as divorced, so the category of "divorced" was dropped in the present study. As shown in Table 3, married students persisted at a higher percentage than did single students: 61.8% vs. 45.0%. There exists a statistically significant difference in marital status between persisters and non-persisters ($p = 0.000$). This finding implies that married students were more likely to persist in engineering. The institutional data did not indicate how long the students had been married, so additional research would be required to narrow down why married students outperformed their single counterparts. Possible reasons for the relative success of married students when compared with single students include projected age at graduation, spousal support, and increased financial stability.

4.6 Significance of residency status on persistence

The institutional data defines student residency status as in-state resident, out-of-state resident, and international student. As seen from Table 3, the vast majority of students (658) were in-state residents because USU is a land-grant state university with the primary mission to serve people in the state of Utah. There exists a statistically significant difference in residency status between persisters and non-persisters ($p = 0.001$). When compared with in-state resident students, out-of-state resident students were less likely to persist and international students were more likely to persist.

Out-of-state resident students pay a much higher tuition rate than in-state resident students at USU. Students with financial concerns are less likely to persist. Additionally, since the majority of engineering students at USU come from in-state, teaching methods and culture are more familiar for in-state residents than out-of-state resident students. International students also pay a much higher tuition than in-state resident students, but this tuition is often subsidized by the students' country of origin. International students rarely work off campus and experience less competing priorities than their resident counterparts. This, of course, does not discount the tremendous language and cultural barriers international students must overcome. The fact that international students persist at such a high rate is a testament to not only the tenacity of the international students, but also to the programs administered by USU to integrate international students.

4.7 Significance of campus residence on persistence

The institutional data used for analysis in the present study included data indicating if students had lived on the main campus of USU. As seen from Table 3, the majority of students (543) did not live on campus. The percentages of persisters for students who lived on campus and who did not live on campus are very close: 50.2% vs. 49.9%. There exists no statistically significant difference ($p = 0.937$) between persisters and non-persisters in terms of whether they lived on campus or not. One possible explanation is the tendency for students to move often at USU. The institutional data indicated if a student had ever lived on campus, but did not indicate where the student may have lived at the point in time a decision on persistence in engineering was made.

4.8 Significance of scholarship on persistence

As seen from Table 3, the majority of students (463) had not received scholarships. The percentage of persisters for students who received scholarships (48.2%) is slightly lower than the percentage of persisters for students who had not received scholarships (51.2%). There exists no statistically significant difference ($p = 0.416$) between persisters and non-persisters in terms of whether students received scholarships or not. In other words, students with scholarships were no more likely to persist in engineering than students without scholarships.

It should be noted, however, that the institutional data did not specify when students received scholarships, the amount or type of the scholarship, and if that scholarship had been maintained. Without this additional information, it is difficult to dismiss scholarships as a factor predictive of persistence in engineering. Two factors would lead the researchers to believe that scholarships are, in fact, predictive of persistence. The first is the tendency of students with financial concerns to drop out at a higher rate. Scholarships may add to the students' sense of financial wellbeing. Secondly, students with scholarships normally perform better academically than students who do not have scholarships. It follows that higher-performing students would be more likely to persist.

4.9 Significance of financial aid on persistence

Table 3 shows that the majority of students (419) received financial aid. The percentage of persisters for students who received financial aid (61.6) is significantly higher than the percentage of persisters for students who had not received financial aid (36.0%). There exists statistically significant difference ($p = 0.000$) between persisters and non-persisters in terms of whether students received financial aid or not. In other words, students who had received financial aid were more likely to persist than those who did not. Similar to students with scholarships, a possible explanation of this finding is the effect financial wellbeing can have on persistence. Students who are comfortable in their financial situation are more likely to persist.

5. Limitations of the present study

The present study has three primary limitations. First, all institutional data employed in this research were collected from one single institution only. As cultural and educational environments vary from institution to institution, the research findings from the present study only apply to those institutions with a similar cultural and educational environment.

Second, the institutional data employed in the present study were limited. For example, although the institutional data provided information on whether or not a student received a scholarship, it did not provide further detailed information on the amount of the scholarship and how often a student received a scholarship. Scholarships from private sources were also not reported in the institutional data. For example, a one-time scholarship of $1,000 and a scholarship of $10,000 each year for multiple years are significantly different in terms of maintaining a student's financial stability. Therefore, how the amount of scholarship affects student persistence could not be investigated in the present study.

Third, because the institutional data were limited, the scope of the analysis of the data provided was also limited. Interesting questions about the findings require further investigations and may warrant their own study. The examples of further investigations include inquiry into why older students outperform their younger peers, what types of financial aid are most effective in increasing student persistence, and why married students persist at a higher rate than single students.

6. Conclusions

This paper has presented a quantitative research study to employ readily available institutional data to determine factors affecting persistence of engineering undergraduates at a public research university in the U.S. Institutional data were primarily extracted from the university's Banner database for a total of 766 students including 383 persistering students and 383 non-persistering students.

The results of statistical analysis show that among 10 factors investigated in the present study, seven factors are associated with persistence of undergraduate engineering students, including high school GPA, ACT math score, composite ACT score, projected age at graduation, marital status, residency status, and financial aid. The other three factors (gender, campus residence, and scholarship) have no effect on student persistence. Students with higher high school GPAs, ACT math scores, and composite ACT scores were more likely to persist in engineering. Older or married students were more likely to persist than younger or single students. When compared with in-state resident students, out-of-state resident students were less likely to persist and international students were more likely to persist. Students who had received financial aid were more likely to persist than those who did not.

The above research findings have practical implications. The institutions with cultural and educational environments similar to Utah State University can adjust entrance criteria to increase the chances of success for students admitted into the engineering program. For example, the institutions can target high-performance students (as measured by their high school GPAs and ACT scores) for engineering studies and provide financial aid to support students. Additionally, orienting incoming students to the demands and procedures of the engineering program while familiarizing students with the research finding from the present study may be beneficial in informing students' early persistence decisions.

References

1. National Science Board, *Science & Engineering Indicators 2016,* National Science Foundation, Arlington, VA, 2016.
2. G. Gerefei, V. Wadhwa, B. Rissing and R. Ong, Getting the number right: International engineering education in the United States, China, and India, *Journal of Engineering Education*, **97**(1), 2008, pp. 13–25.
3. N. Augustine, Danger: America is losing its edge in innovation, http://www.forbes.com, Accessed 10 March 2106.
4. R. A. Wolk, Wasting minds, Why our education system is failing and what we can do about it, Association for Supervision & Curriculum Development, Alexandria, VA, 2011.
5. B. N. Geisinger and D. Rajraman, Why they leave: Understanding student attrition from engineering majors, *International Journal of Engineering Education*, **29**(4), 2013, pp. 914–925.
6. E. Seymour and N. M. Hewitt, *Talking About Leaving: Why Undergraduates Leave the Sciences,* Westview Press, Boulder, CO, 1997.
7. House Committee on Science, Subcommittee on Research, *Undergraduate Science, Math, and Engineering Education: What's Working*? 109th Cong., 2nd Sess., March 15, 2006.
8. A. Akay, The renaissance engineer: Educating engineers in a post-9/11 world, *European Journal of Engineering Education*, **28**, 2003, pp. 145–150.
9. P. H. Hsieh, Undergraduate engineering students' beliefs, coping strategies, and academic performance: An evaluation of theoretical models, *The Journal of Experimental Education*, **80**(2), 2012, pp. 196–218.
10. T. Tseng, H. L. Chen and S. Sheppard, Early academic experiences of non–persisting engineering undergraduates, *Proceedings of the 118th American Society for Engineering Education Annual Conference and Exposition*, Vancouver, British Columbia, Canada, June 26–29, 2011.
11. W. Tyson, Modeling engineering degree attainment using high school and college physics and calculus course taking and achievement, *Journal of Engineering Education*, **100**(4), 2011, pp. 760–777.
12. M. Laugerman, D. Rover, M. Shelley and S. Mickelson, Determining graduation rates in engineering for community college transfer students using data mining, *International Journal of Engineering Education*, **31**(6A), 2015, pp. 1448–1457.
13. O. Eris, D. Chachra, H. Chen, S. Sheppard, L. Ludlow, C. Rosca and G. Toye, Outcomes of a longitudinal administration of the persistence in engineering survey, *Journal of Engineering Education*, **99**, 2010, pp. 371–391.
14. M. Borrego, E. P. Douglas and C. T. Amelink, Quantitative, qualitative, and mixed research methods in engineering education, *Journal of Engineering Education*, **98**(1), 2009, pp. 53–66.
15. S. Hurtado, K. Eagan and M. Chang, *Degrees of Success: Bachelor's Degree Completion Rates Among Initial STEM Majors,* Higher Education Research Institute, University of California, Los Angeles, 2010.
16. J. R. Duncan and Y. Zeng, *Women: Support Factors and Persistence in Engineering,* National Center for Engineering & Technology Education (NCETE), Utah State University, Logan, UT, 2005.
17. E. Godfrey, T. Aubrey and R. King, Who leaves and who stays? Retention and attrition in engineering education, *Engineering Education*, **5**(2), 2001, pp. 26–40.
18. S. Haag, N. Hubele, A. Garcia and K. McBeath, Engineering undergraduate attrition and contributing factors, *International Journal of Engineering Education*, **23**, 2007, pp. 929–940.
19. C. D. Schmidt, G. B. Hardinge and L. J. Rokutani, Expanding the school counselor repertoire through STEM-focused career development, *Career Development Quarterly,* **60**(1), 2012, pp. 25-35.
20. C. T. Amelink and P. S. Meszaros, A comparison of educational factors promoting or discouraging the intent to remain in engineering by gender, *European Journal of Engineering Education*, **36**(1), 2011, pp. 47–62.
21. W. Tyson, Negative impact of employment on engineering student time management, time to degree, and retention: Faculty, administrator, and staff perspectives, *Journal of College Student Retention: Research, Theory & Practice*, **13**, 2012, pp. 479–498.
22. K. Trigwell, M. Prosser and P. Taylor, Qualitative differences in approaches to teaching first year university science, *Higher Education*, **27**(1), 1994, pp. 75–84.
23. A. Austin, M. Connolly and C. Colbeck, Strategies for preparing integrated faculty, *New Directions for Teaching & Learning*, **113**, 2008, pp. 69–81.
24. L. K. Newswander and M. Borrego, Engagement in two interdisciplinary graduate programs, *Higher Education*, **58**, 2009, pp. 551–562.
25. J. D. Nyquist, L. Manning, D. H. Wulff, A. E. Austin, J. Sprague, P. K. Fraser, C. Calcagno and B. Woodford, On the road to becoming a professor: The graduate student experience, *Change: The Magazine of Higher Learning*, **31**(3), 1999, pp. 18–27.
26. S. Herzog, Estimating student retention and degree-completion time: Decision trees and neural networks vis-à-vis regression, *New Directions for Institutional Research*, **131**, 2006, pp. 17–33.
27. C. Caroni, Graduation and attrition of engineering students in Greece, *European Journal of Engineering Education*, **36**(1), 2011, pp. 63–74.
28. M. W. Ohland, S. D. Sheppard, G. Lichtenstein, O. Eris, D. Chachra and R. A. Layton, Persistence, engagement, and migration in engineering programs, *Journal of Engineering Education*, **97**, 2008, pp. 259–278.
29. V. Morganson, Understanding women's underrepresentation in science, technology, engineering, and mathematics: The role of social coping, *The Career Development Quarterly*, **60**(1), 2010, pp. 25–35.
30. R. Suresh, The relationship between barrier courses and persistence in engineering, *Journal of College Student Retention: Research, Theory & Practice*, **8**, 2007, pp. 215–239.
31. H. Hartman and M. Hartman, Leaving engineering: Lessons from Rowan Univ's college of engineering, *Journal of Engineering Education*, **95**(1), 2006, pp. 49–61.
32. G. Zhang, T. J. Anderson, M. W. Ohland and B. R. Thorndyke, Identifying factors influencing engineering student graduation: A longitudinal and cross-institutional study, *Journal of Engineering Education*, **93**(4), 2004, pp. 313–320.
33. Ellucian, http://www.ellucian.com, Accessed March 10, 2016.
34. SPSS software, http://www-01.ibm.com/software/analytics/spss, Accessed March 10, 2016.
35. ABET, http://www.abet.org, Accessed March 10, 2016.
36. R. Hogg, *Modern Statistics, Methods and Applications*, American Mathematical Society, San Antonio, TX, 1980.

Matthew Meyer is a recent graduate of the Engineering Education PhD program at Utah State University. He is employed as a manager of a large water and wastewater engineering company. His research interests include qualitative and quantitative inquiry into persistence in engineering education.

Ning Fang is a Professor in the Department of Engineering Education at Utah State University, USA. He has taught a variety of courses at both graduate and undergraduate levels, such as engineering dynamics, metal machining, and design for manufacturing. His areas of interest include computer-assisted instructional technology, curricular reform in engineering education, and the modeling and optimization of manufacturing processes. He earned his PhD, MS, and BS degrees in mechanical engineering and is a Senior Member of the Society for Manufacturing Engineering (SME) and a member of the American Society of Mechanical Engineers (ASME) and the American Society for Engineering Education (ASEE).