
AC 2011-1968: EARLY ACADEMIC EXPERIENCES OF NON-PERSISTING ENGINEERING UNDERGRADUATES

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Abstract

Engineering programs nationwide lose almost half of their undergraduate students during the course of their undergraduate careers. Increasing our understanding of the students who leave engineering (“non-persisters”) is crucial to determine ways to better support engineering undergraduates and increase retention. This study utilizes academic transcripts and interviews collected from the Academic Pathways Study (APS) to understand persisting and non-persisting students from a Suburban Private University (SPri). Data from the APS allow for characterization of the coursework the students take and exploration of their experiences with and reactions to engineering coursework. In particular, differences between experiences of persisters and non-persisters in their first two years of study are compared to identify factors that may strongly influence non-persisters to switch out of engineering.

Prior research on the same data set has found that at the onset of their first year, non-persisters are already less intent on finishing an undergraduate major, and they experience a sharp decrease in intrinsic psychological motivation to continue studying engineering after their first year. The current work shows that non-persisters do not take significantly less engineering coursework than their peers during their first year, and students who ultimately choose non-engineering majors exhibit a marked decrease in the amount of engineering coursework they take at the beginning of the sophomore year. Students do not differ in grades or confidence in math and science, suggesting that differences in ability may not be a primary reason for switching. Both groups of students appear to undergo the same hardships of curriculum overload due to inflexible and overwhelming course requirements for engineering majors. However, interview data suggest that persisters and non-persisters deal with academic difficulties differently and have varying opinions about the relevance and importance of prerequisite engineering coursework. Furthermore, those who matriculated intent on majoring in engineering but who eventually go on to switch majors report a steady decrease in their intention to complete an engineering major through the course of their first year; this suggests that while these students may be taking the same courses as the persisters, they may be experiencing them in a very different way.

Introduction

Ongoing concerns about a future shortage of practicing have resulted in increased attention to the concept of “persistence” or retention of undergraduate students in engineering education^{1,2}. We further distinguish persistence into two categories – *academic persistence* which is defined as the intention to complete an engineering major and *professional persistence* which describes the intention to become a practicing engineering after graduation.

A number of studies focusing on identifying the factors that influence academic persistence have employed a range of cross-sectional and longitudinal research designs and qualitative and quantitative methodologies. Seymour and Hewitt (1997) interviewed over 300 juniors and seniors at seven institutions to understand their reasons for switching to majors outside of science, mathematics, or engineering (SME)³. Significant factors included a loss of interest in

science and being overwhelmed by curriculum demands. Comparisons between the students who switched and those who stayed in SME majors revealed differences in approaches and coping strategies but not in the reasons for changing majors. Furthermore, the transition from freshman to sophomore year was found to be a critical period for switching out of engineering.

Analyses of the academic transcripts of engineering students were the focus of Adelman's (1998) exploration of 11 years of college transcript history from the High School and Beyond/Sophomore Cohort Longitudinal Study (1982-93) and the Cooperative Institutional Research Program (CIRP) Survey⁴. "Perception of overload" or "academic dissatisfaction" was identified as a contributing factor to leave engineering for both men and women. More recently, Ohland et al. (2008) and Lord et al. (2009) have drawn upon the Multiple-Institution Database for Investigating Engineering Longitudinal Development (MIDFIELD), a longitudinal collection of student records from over 70,000 engineering students at nine institutions to delve more deeply into questions related to institutional differences in the undergraduate engineering experience as well as the impact of individual differences related to gender and ethnicity on persistence^{5,6}. Ohland et al. (2008) has determined that non-persistence in engineering majors is not dissimilar from non-engineering majors since students non-persist at a similar rate. However, migration into engineering majors is much lower than that of non-engineering majors, suggesting that the majority of students who go on to earn an engineering degree usually begin their undergraduate studies committed to completing the major.

Surveys have also been developed and deployed cross-sectionally and longitudinally to track the correlates of persistence. Besterfield-Sacre, et al. developed the Pittsburgh Freshman Engineering Attitudes instrument as a tool to address attrition and performance in a freshman engineering program and facilitate understandings in gender differences among students' attitudes towards engineering^{7,8}. In prior studies, female students have had significant lower confidence in succeeding in their engineering program. However, differences in confidence did not manifest in GPAs, as female students and male students did not differ in their academic performance.

Other survey instruments focusing on the correlates persistence have been developed by the Center for the Advancement in Engineering Education including the Persistence in Engineering (PIE) survey which assessed persistence longitudinally at four institutions^{9,10} and the Academic Pathways of People Learning Engineering Survey (APPLES) instrument which was administered cross-sectionally in a national study of engineering students at 21 institutions¹¹.

Eris et al. (2010) used academic transcript data from 160 students to identify both persisters (P in Figure 1) and engineering non-persisters – students who had decided to not major in engineering¹². These engineering non-persisters were less committed to completing their prospective engineering major even at the onset of their first year. Eris et al. (2010) goes further to categorize the engineering non-persisters according to when they declared a non-engineering major, e.g. by the spring semester of their first year (NP2), by the fall semester of their second year (NP3), or by the spring semester of their second year (NP4). Figure 1 shows that among the non-persisters who responded to the PIE survey question, "Do you intend to complete a major in engineering?", students who made the decision to not major in engineering earlier in their

undergraduate career (e.g., NP2) reported lower intention to persist in engineering as compared to those students who made the decision later in their career (e.g., NP4).

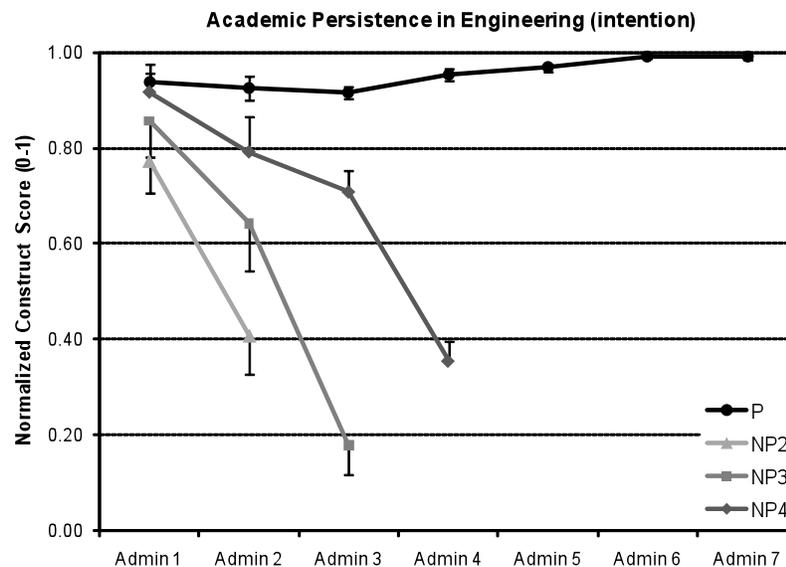


Figure 1: Reported intention to major in engineering across Persistence in Engineering Survey Administrations by the Academic Pathways Study longitudinal cohort¹⁰

Non-persistence in engineering is a complex issue that arises from a variety of factors. As 40 percent of students who start their education in engineering decide to switch majors⁵, identifying the factors that contribute to non-persistence is critical¹³. Research aimed at establishing a greater understanding of non-persistence can enable engineering schools and departments to provide better support for undergraduates in their paths to completing an engineering degree and can lead to interventions in the critical periods when most students are making the decision to not continue in engineering.

The current work builds upon the findings of Eris et al.¹⁰ to more closely examine the differences between persisting and non-persisting students based on their coursework in their freshman and sophomore years and their perceptions of engineering as the result from taking these courses. Drawing upon academic transcript and qualitative interview data from the Academic Pathways Study, the following questions are addressed:

RQ1: *Do persisting and non-persisting students differ in the number and types of engineering coursework they take?*

RQ2: *Do persisting and non-persisting students differ in their grades in engineering classes?*

RQ3: *How do non-persisting students experience engineering coursework compared to persisting students?*

Academic Pathways Study & Suburban Private Institute

The Academic Pathways Study (APS) started in the fall of 2003 with the goal of better understanding students' experiences in engineering programs and their transition into the engineering workforce. It includes a longitudinal study of students at four different institutions over the four years of their undergraduate careers. Students in the study participated in online surveys and in-person structured and ethnographic interviews. Structured and ethnographic interviews were administered every spring starting in the first year^{14,15}.

While the APS incorporates data from four institutions, preliminary analyses utilized in this paper was restricted to a single school. Variations in curriculum requirements, admission procedures, and student body would complicate comparisons between students from different institutions. Examining a single school enables a more contextualized review of coursework and experiences of the students in the study relative to the school's requirements and mission.

This paper focuses on the experiences of persisting and non-persisting APS students from the Suburban Private University (SPri). Suburban Private University (SPri) is a research institution with an enrollment of approximately 14,000 undergraduate and graduate students. About 320 to 350 incoming freshmen (out of a total of 1600 first year students) self-identify as prospective engineering majors. Prospective engineering students do not apply directly to SPri's school of engineering but instead declare an engineering major at any time during their undergraduate and do not need to declare a major until the start of their junior year. Selection into the APS was based on interest in majoring in engineering as indicated through academic surveys sent to students in the summer before matriculation. SPri is on the quarter system (vs. semester), and all students must complete a minimum of 180 units in order to graduate.

Course Requirements for Engineering Majors at SPri

Engineering students at SPri are required to take engineering coursework that fall into three categories: math and science requirements, engineering foundations, and engineering depth courses. Math and science requirements are set forth by each student's intended engineering major; for most engineering students, math and science requirements involves approximately 40 units of basic chemistry, physics, or biology along with calculus coursework. Most students opt to fulfill most of their math and science requirements during their freshman and sophomore years.

Engineering majors are also required to take foundational engineering coursework. These engineering foundation courses differ slightly by major but most often include basic engineering coursework such as statics or computer programming. The purpose of these classes is to expose students to broad engineering topics and fields of engineering, enable incoming students to explore courses before declaring a specific engineering major, and provide insights into contemporary subject areas for non-engineers. Engineering foundations are not offered by a particular engineering department; in contrast, engineering depth courses are within a student's department.

Engineering depth courses consist of approximately 40 units of the core coursework for a

student's chosen engineering major. They enable undergraduates to develop expertise in their major as well as gain experience in a variety of department-specific subjects.

Engineering seminar courses are typically not required but encouraged, particularly for freshmen students. A series of introductory seminars targets freshmen and sophomore students specifically to expose them to research areas within a department. Other departmental seminars consist of weekly talks given by invited speakers from industry and research, thereby enabling students to learn about a broad range of engineering applications. Seminars are typically one to three units and may be graded on a pass / fail basis.

Students at SPri also have the opportunity to take independent study units to participate in research projects with faculty and their graduate students. Involvement in this kind of activity can allow the students to build a mentoring relationship with their supervising faculty member and also represent another means to learn about different aspects of the engineering field through engagement in research activities outside of formal courses.

Outside of their engineering coursework, students at SPri are required to meet general education requirements set forth by the institution. These requirements include eight courses in the humanities and social science (three of which need to be taken by the end of freshman year), three writing courses, and three foreign language courses. Thus, engineering students at SPri may not engage in as much engineering coursework during their first year compared with students at specialized technical institutions.

While 180 quarter units are required to graduate from SPri, engineering majors at SPri are required to take more units than their non-engineering peers and as a result, have less flexibility to take electives and other courses outside of their departmental requirements. On average, majors within the school of engineering require a minimum of 109 units. In contrast, majors within the earth sciences require 93 units, and majors within humanities and sciences require 65 units. A typical course load within the SPri's quarter system is 15-17 units per quarter, with an individual engineering course averaging 3 to 4 units per course.

Methodology

Description of Dataset

This paper draws upon the academic transcripts and interview transcripts of 38 SPri students collected as part of the Academic Pathways Study. Twelve students in this sample were female (32%). Academic transcripts enabled close examination of the coursework taken by persisting and non-persisting students. In particular, differences in the number of engineering courses, types of engineering classes taken, and grades within these courses were studied to reveal possible differences in course-taking patterns by persisters and non-persisters.

Semi-structured and ethnographic interviews were used to incorporate the students' voices about engineering coursework, difficulties they experienced as engineering students, and students' perceptions of engineering more broadly. Overall, the interviews shed light on issues and trends that emerged from the quantitative analysis of student coursework and grades.

To supplement the academic transcript and qualitative interview data are SPri students' responses to the question "Do you intend to complete a major in engineering?", which was asked in the Persistence in Engineering (PIE) survey that was administered four times during the first two years of the Academic Pathways Study. Collected during the winter and spring quarters of the freshman year and the fall and spring quarters of the sophomore year, these self-reports represent another measure of persistence based on student intention.

Non-Persisters

Twelve SPri students (32%) non-persisted during the course of their undergraduate careers (NPs). Of these twelve students, three were female (25%). Non-persisters represented a variety of different majors; four students graduated with a BA degree (majoring in Philosophy, Linguistics, International Relations, and Philosophy) while eight non-persisters graduated with a BS degree (with majors such as Biology, Physics, and Economics). Of those students who received a BS degree, four majored in an interdisciplinary major combining computer science, psychology, and philosophy.

All non-persisters reported switching out of engineering by the end of their second year. The time of non-persistence was gathered from academic transcript data collected at the end of each academic quarter. One student non-persisted after the spring of their first year, five non-persisted after the fall of their second year, and the remaining six non-persisted after the end of their second year.

Persisters

Twenty-six persisters (Ps) were included in this study and satisfied the requirement of being a full-time student during the first two years of their undergraduate studies. Their majors included Electrical Engineering, Mechanical Engineering, Aeronautics and Astronautics, and Biomechanical Engineering.

Coursework Analysis

The academic transcripts utilized provided information on the courses taken by each student, the number of units each course was taken for, and each student's final grade in the course. Since all non-persisting students were reported to have non-persisted by the end of the second year, only data corresponding with the first two years of study were analyzed.

All engineering coursework was classified into one of five categories: math and science requirements, engineering foundations, engineering depth courses, engineering seminars, and engineering research credit. Double-sided t-tests were used to compare the number of units taken by persisters and non-persisters, and differences were considered significant at a level of $p < 0.05$. Non-persisters were further distinguished as those who graduated with BS degrees (BS NPs) versus those who graduated with BA degrees (BA NPs). Distinguishing between these two types of non-persisters helped elicit further differentiation in both the kinds of courses and course taking patterns of non-persisting students.

Interview Analysis

Semi-structured and ethnographic interviews conducted at the end of the first and second years were analyzed to gain a more comprehensive understanding of the experiences of the persisters non-persisters both before and after their non-persistence. Each student was interviewed individually and asked questions pertaining to their experiences as an engineering student. A total of 30 students participated in the first semi-structured interview (22 Ps and 8 NPs) while 23 students participated in the second semi-structured interview (16 Ps and 7 NPs). In addition, ethnographic exit interviews were also conducted with eight of the twelve non-persisting students.

Interviews were coded using a grounded-theory approach¹⁶. Frequencies of codes that emerged from the data were then used to identify the most commonly cited problems students faced in their engineering programs. Influential factors for non-persisting were coded, which was further separated into two categories: reasons for choosing a new major and reasons for leaving engineering.

Results

Coursework Analysis

RQ1: Do persisting and non-persisting students differ in the number and types of engineering coursework they take?

To answer the first part of the question, the cumulative number of engineering or technical courses taken by all 38 students over their freshmen and sophomore years was determined. Courses that counted as engineering or technical coursework in the current study were ones that fulfilled requirements for an engineering degree and include math and science requirements, engineering foundations, engineering depth courses, engineering seminars, and engineering research credit. Because all non-persisting students were reported as having selected a non-engineering major by the sixth quarter, the current analyses are limited to the first six quarters (or two years).

Table 1 shows the quarter-by-quarter number of course units taken by students in each of the three groups (persister (P), non-persisters who eventually receive a BS degree (BS NPs), and non-persisters who eventually receive a BA degree (BA NPs)) by each of the engineering coursework categories. The total number of engineering course units by quarter is shown in the last column, along with a cumulative summary of units taken in the freshman and sophomore years. Statistically significant differences between persisters and each non-persister group are indicated.

Table 1: Units taken each quarter by Persisters, BS Non-Persisters, BA Non-Persisters by engineering coursework category

		Math & Science Requirements Mean (SD)	Engineering Foundations Mean (SD)	Engineering Depth Mean (SD)	Engineering Seminars Mean (SD)	Engineering Research Mean (SD)	Quarter Engr. Cumulative Mean (SD)
Q1	P	6.27 (3.08)	0.88 (2.35)	0.38 (1.36)	0.62 (1.10)	0.15 (0.37)	8.31 (2.57)
	BS NPs	6.00 (3.07)	0.62 (1.77)	0.00 (0.00)	0.25 (0.47)	0.00 (0.00)	6.87 (1.81)
	BA NPs	4.75 (3.69)	1.25 (2.50)	0.00 (0.00)	0.25 (0.50)	0.00 (0.00)	6.25 (1.90)
Q2	P	5.31 (3.25)	0.73 (1.76)	0.31 (1.12)	1.23 (1.45)	0.04 (0.20)	7.62 (3.20)
	BS NPs	4.13 (5.25)	1.25 (2.31)	0.50 (1.42)	0.50 (0.76)	0.00 (0.00)	6.38 (4.28)
	BA NPs	3.50 (4.36)	1.25 (2.50)	0.00 (0.00)	0.25 (0.50)	0.00 (0.00)	5.00 (3.26)
Q3	P	4.31 (3.47)	1.50 (2.58)	0.81 (1.44)	0.54 (1.24)	0.00 (0.00)	7.15 (2.82)
	BS NPs	2.75 (4.17)	0.00 (0.00)	0.50 (1.42)	0.00 (0.00)	0.00 (0.00)	3.25 (4.03)**
	BA NPs	4.01 (2.71)	0.00 (0.00)	0.75 (1.42)	1.25 (1.90)	1.00 (2.00) **	7.01 (2.45)
			Freshman Year Engineering Cumulative			P	23.08 (6.06)
			Freshman Year Engineering Cumulative			BS NPs	16.50 (8.79) *
			Freshman Year Engineering Cumulative			BA NPs	18.26 (4.34)
Q4	P	3.19 (3.02)	2.84 (3.34)	3.54 (3.29)	0.46 (0.90)	0.19 (0.80)	10.23 (3.86)
	BS NPs	3.62 (3.33)	0.62 (1.77)	1.25 (2.81)	0.00 (0.00)	0.00 (0.00)	5.50 (4.44) **
	BA NPs	2.25 (2.63)	0.00 (0.00)	0.00 (0.00) *	1.00 (2.00)	0.00 (0.00)	3.25 (2.22) **
Q5	P	1.35 (2.50)	1.08 (1.87)	5.89 (4.00)	0.31 (1.01)	0.04 (0.2)	8.66 (3.62)
	BS NPs	1.00 (1.93)	0.62 (1.77)	2.12 (2.36)*	0.00 (0.00)	0.00 (0.00)	3.75 (3.80)**
	BA NPs	1.75 (2.06)	0.00 (0.00)	1.25 (2.50)*	0.50 (1.01)	0.00 (0.00)	3.50 (3.41)*
Q6	P	1.35 (3.03)	1.69 (2.11)	6.66 (5.01)	0.23 (0.82)	0.23 (0.71)	10.16 (3.95)
	BS NPs	0.62 (1.77)	0.62 (1.77)	1.62 (2.32)*	0.00 (0.00)	0.00 (0.00)	2.87 (3.22)***
	BA NPs	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)*	0.75 (1.50)	0.00 (0.00)	0.75 (1.50)***
			Sophomore Year Engineering Cumulative			P	29.05 (8.97)
			Sophomore Year Engineering Cumulative			BS NPs	12.12 (7.39) ***
			Sophomore Year Engineering Cumulative			BA NPs	7.50 (5.45) ***

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.0001$

One observation that emerges from Table 1 is that all students in the study take less than, on average, 25 percent of their 15 units per quarter (typical course load) in math and science coursework. Depending on their specific major within engineering, department requirements range from 40 to 50 units. Even for the persisters, by the end of the sophomore year they have taken an average of 21.8 math and science units. This is indicative of two things: a fair number of students come in with AP units, and they will continue to take math and science courses in their junior and senior years. For all three groups, the greatest number of units in math and science are taken the first quarter, which then tapers off (see Table 2). The students seem to be following the advice in SPri’s engineering student handbook for first year courses:

The best strategy is to avoid the extremes. A first-year schedule that includes no mathematics, science, or engineering will make it very difficult to complete an engineering major in four years. Conversely, it is surely a recipe for disaster to insist on packing your first year with three quarters each of calculus, physics, and chemistry along with the mandatory Introduction to the Humanities and Program in Writing and Rhetoric classes. There is too much work in each of those courses to take them all at the same time, particularly before you’ve had a chance to acclimate to SPri’s intensity and rapid pace. You should seek an appropriate balance for your studies. (Engineering Handbook, 2004-2005, pg. 2)

Table 2: Math and Science units by persister status and by quarter

		Persisters M (SD)	BS Non-Persisters M (SD)	BA Non-Persisters M (SD)
Math & Science Requirements	Q1	6.27 (3.08)	6.00 (3.07)	4.75 (3.69)
	Q2	5.31 (3.25)	4.13 (5.25)	3.50 (4.36)
	Q3	4.31 (3.47)	2.75 (4.17)	4.01 (2.71)
	Q4	3.19 (3.02)	3.62 (3.33)	2.25 (2.63)
	Q5	1.35 (2.50)	1.00 (1.93)	1.75 (2.06)
	Q6	1.35 (3.03)	.62 (1.77)	0.00 (0.00)

Table 1 also shows that students from all groups are taking less than three units of engineering foundations, engineering depth and engineering seminar courses per quarter during their freshman year. In terms of courses, this is less than one course per quarter. And yet these courses are, in principle, there to help them explore engineering. As described in the handbook, the goal of the engineering foundations courses are to “provide a breadth of knowledge about some of the major fields within engineering,” and to “furnish students with an opportunity to explore a number of engineering topics before embarking on a specific engineering major.” (Engineering Handbook, 2004-2005, pg. 20)

Extending this picture to the end of the sophomore year, we see that persisters are by then taking a little more than 50 percent of their units in engineering foundational and depth courses. They are still “ramping up” into engineering and appear to be following the advice in the SPri’s engineering handbook (though this is not without stress, as we discuss in RQ3):

As an undergraduate, you should take the time to explore that wealth of academic excellence. Committing yourself prematurely to one discipline or coming in with too-

firmly fixed ideas of exactly where you are going can take away from your chances to discover what SPri has to offer, and to take advantage of all its diversity. SPri encourages academic exploration by not requiring you to make a commitment up front; at many universities, students are asked to declare their intended major as part of the application process, particularly if they are interested in engineering. Not so at SPri. Here, you need not declare a major until the beginning of your junior year. You have the time to explore different possibilities before settling on a major. (Engineering Handbook, 2004-2005, pg. 1)

However, we do begin to see differences between persisters and non-persisters at the beginning of the first term of the sophomore year (Q4). Persisters are taking more engineering foundation and depth courses than are non-persisters. We also see a difference (though not statistically significant) in the types of engineering coursework taken by BS NPs and BA NPs, with BS NPs taking more engineering foundations and depth courses than BA NPs during all three quarters of the sophomore year. As previously mentioned, by their sixth quarter (end of sophomore year), over 50 percent of the coursework taken by persisters is engineering in nature, as compared to the content of the courses taken by BS NPs and BA NPs as seen in the choice of courses taken from Q4 to Q6.

Based on the courses taken during the first (freshman) year, it is not possible to predict which students will decide to switch out of engineering and of these non-persisters, whether these students will head towards BS vs. BA fields. All of these students are taking math and science courses as well as a few exploratory courses in engineering (through foundational courses and seminars). Their schedules are also constrained due to the structure of the first year at SPri and the significant general education requirements.

While engineering course units does not differentiate persisters from non-persisters during their first year of college, we did see among the SPri students a growing gap in their answers to the PIE question “Do you intend to complete a major in engineering?” as noted in Figure 1. The answer for persisters (on a normalized scale of 0-1) remains near one from freshman year to the end of sophomore year. However, for non-persisters (both BS NPs and BA NPs), the answer is near unity in the middle of their freshman year but decreases by the end of the freshman year to 0.70 and continues to decline for non-persisters to 0.16 by the end of the sophomore year.

RQ2: Do persisting and non-persisting students differ in their grades in engineering classes?

Students’ grade point averages (GPA) in their engineering coursework were calculated and compared at two points: after the first year and after the second year. Analyses were performed on GPA after the first year since not all non-persisting students had declared their intention to switch majors by this point. The second year was used as a second point of a comparison since all non-persisters had switched by the end of the second year.

Table 3: Engineering GPA of persisting and non-persisting students (on a 4.0 scale)

	Engr. GPA After First Year Mean (SD)	Engr. GPA After Second Year Mean (SD)
P (n=26)	3.30 (0.52)	3.32 (0.55)
BS NPs (n=8)	3.39 (0.29)	3.58 (0.65)
BA NPs (n=4)	2.84 (1.1)	2.88 (1.17)

At the end of the first year, there were no statistically significant differences in the engineering GPA of persisting and non-persisting students. In fact, students who went on to non-persist and pursue a BS degree outside of engineering have a slightly higher average GPA than persisters. In contrast, students who eventually received a BA degree had slightly lower GPAs although this difference is not statistically significant.

After the second year, there were still no statistically significant differences between persisters and non-persisters. Furthermore, there were no statistically significant drops or increases in GPA from the first year to second year. Although non-persisting students take less engineering coursework overall than their persisting peers, it appears that they do not receive significantly lower grades in the engineering courses they do take. This result suggests that non-persistence is not influenced by lower academic performance or ability in engineering coursework.

Students' GPAs in math and science courses were analyzed as a point of comparison to prior work highlighting the importance of early calculus coursework on persistence¹⁷. As can be seen in Table 4, similar trends appear compared with overall engineering GPA. BS non-persisters have slightly higher GPAs in math and science courses than persisting students while BA non-persisters have slightly lower GPAs; however, these differences are not statistically significant. Again, the differences between grades at the end of the first and second year are also not significant.

Table 4: Math & science GPAs of persisting and non-persisting students (on a 4.0 scale)

	Math & Science GPA After First Year Mean (SD)	Math & Science GPA After Second Year Mean (SD)
P (n=26)	3.35 (0.56)	3.32(0.55)
BS NPs (n=8)	3.50 (0.65)	3.58 (0.65)
BA NPs (n=4)	2.87 (1.10)	2.88 (1.17)

Finally, students were asked to rate their confidence in their math and science abilities during each of the first two structured interviews (after the first year and after the second year). On average, persisters have increased their confidence in their math and science ability from the first year to the second while non-persisters have the same confidence level in math but have decreased confidence in science. However, with the exception of a significant difference between persisters and non-persisters in science confidence after the second year, there are no other differences between groups. Confidence ratings after the first year are not statistically different from corresponding self ratings after the second year. These results suggest that there is little difference between persisters and non-persisters in confidence in academic areas and

reinforces the idea that confidence and ability in core academic subjects does not appear to influence non-persistence for this particular set of students.

Comparing coursework and grades of persisting and non-persisting students revealed that there is little difference between persisting and non-persisting students in the number of engineering courses taken during the first year. Differences begin to appear at the start of the second year. Analysis of students' GPAs reveals that grades in engineering coursework are not statistically different among participants. As a result, it appears that performance within courses may not necessarily be a main factor contributing to non-persistence. Similar confidence ratings in math and science ability emphasize the idea that non-persisters are similarly confident in their academic skills compared with persisters.

To better understand factors influencing students to switch majors, interview transcripts were analyzed and coded for contributing factors affecting non-persistence.

Interview Analysis

Analysis of semi-structured and ethnographic interviews conducted in the first two years were used to answer the remaining research question:

RQ3: How do non-persisting students experience engineering coursework compared to persisting students?

All non-persisting students experienced various difficulties that may have played a role in their decision to switch majors out of engineering. In particular, coursework was critical to non-persisters' dissatisfaction with their engineering major; curriculum overload, or the large number of requirements students must fulfill to earn an engineering degree, lack of academic flexibility, and the workload of engineering coursework were the most commonly cited factors in students' responses to the question: "Are there any aspects about being an engineering major at [SPri] that you find particularly difficult in achieving your academic goals?" These factors were prevalent in both the first and second structured interviews, indicating that problems with coursework were experienced during both freshman and sophomore years. Furthermore, academic factors were commonly mentioned by persisting students as well, evincing that academic pressures and difficulties were experienced by most engineering students in the study.

Frustration with engineering coursework is critical because engineering classes were also cited as the most commonly mentioned source for gaining general engineering knowledge, both for persisting and non-persisting students. As a result, required coursework, particularly classes taken in the first two years, are fundamental to students' impressions and perceptions of engineering as a whole.

Academic difficulties faced by persisting and non-persisting students were coded under two categories: curriculum overload and disinterest in engineering pre-requisite coursework. These categories will be discussed in the following sections. We then go on to consider other factors that might influence the experiences of non-persisters that may affect their decision to select a

major outside of engineering, namely discovering other intellectual interests and faculty advisors.

Curriculum Overload

“Curriculum overload” describes the stress and anxiety students experience from having to fulfill the number of course requirements for an engineering major. Both persisting and non-persisting students struggled with taking a large number of engineering classes, which required them to take engineering-related courses early on in their undergraduate careers. As a result, students may not be able to explore other majors because they fear they will not finish their requirements in four years. For example, a non-persisting student described his efforts to pursue two interests: electrical engineering and biology. Realizing that pursuing double majors would be too difficult, he attempted to commit to a minor in biology:

...with much of the requirements for engineering, I decided to do a minor in biology. And even after that like I found that it would be fairly tough and I wouldn't be able to do things that I fairly enjoyed. I find that many of the requirements are fairly taxing, and I didn't want to devote my whole undergraduate experience to engineering even though I may want to do something related but not exactly [to] electrical engineering (BS Non-persister, Structured Interview 2).

Similarly, persisting students also experienced difficulties with having to begin engineering requirements as soon as possible to graduate on time. As a persisting student describes, engineering requirements tend to force students to commit to an engineering track as early as their freshman year:

I just remember my advisor fresh[man year]...[At] one of our first meetings, she was saying something along the lines of, “Well it doesn't really matter what you take now because you can always major in something else later.” And then she was like, “Unless you're going to be EE or CE, in which case you need to start right now!” It was just that attitude that makes engineering majors so much more difficult and huge in size and complexity...I'm forced to choose earlier than other people. I feel like if I'm not taking the classes now then I'm going to run out of time (Persister, Structured Interview 1).

One persisting student articulated the idea of curriculum overload with respect to the number of prerequisites required:

I kind of regret the fact that I have...so many pre-req classes that I need to battle through before I even see what real engineering classes are like. So, in order to even consider engineering, I have to go through all these things and then ultimately the engineering might not even hinge on those beginning principles that much. It depends on what I do. It would be better if I had an earlier introduction to doing engineering problems (Persister, Structured Interview 1).

Many non-persisting students spoke about the decreased number of units required of their new major, which gave them hope of finishing their requirements in time to graduate in four years.

For example, one student discussed the possibility of pursuing a double major in mathematics and physics, which would be more manageable than attempting to complete a double major with engineering. Furthermore, students found their engineering courses to be more time consuming and difficult than classes outside of their major.

The difficulty of engineering coursework coupled with the number of units required makes the engineering curriculum particularly overwhelming for students. However, although both persisting and non-persisting student experienced curriculum overload, they had different outlooks on their required classes. One persisting student stated the following:

It's a lot of work. But I don't know if I can really say I dislike the work because it wouldn't be as rewarding if there wasn't that much work involved (Persister, Structured Interview 1).

For this student, the outcomes of taking engineering courses was rewarding partly because of the hard work that he put into them. Another persisting student discussed her learning in her engineering classes:

It'd be nice to take the other classes and know more. But I don't mind taking the engineering classes because I feel like I'm also learning in those. And so it's not really too big a trade off for me. But sometimes I just kind of wish that I could get a break from this and do other stuff (Persister, Structured Interview 2).

In contrast, several non-persisting students found pursuing a different major with less stringent requirements to be a more promising route.

With what I was doing here at [SPri] in addition to classes, I knew I didn't have the time to devote to being in a major that was 120 units and as intense as [Engineering major] was. When I came to that realization, it was a little bittersweet, but at the same time I realized that there were a lot of other things at [SPri] I could do, so I wasn't too hung up on it (BA Non-persister, Exit Interview).

Next quarter will be some more difficult classes in the [Multidisciplinary Systems] department, but I feel like they're in diverse enough subjects, and that because I also get to balance them out with some [other] classes, I have a much more positive attitude towards them than I did towards computer science (BS Non-persister, Exit Interview)

It appears that although both persisters and non-persisters experience hardships associated with curriculum overload, persisters were more likely to find the requirements to be worthwhile. Some non-persisters found that alternative majors with fewer requirements were a better option. Curriculum overload often prevented students from having the flexibility to pursue other academic and non-academic pursuits such as participating in extracurriculars, taking courses outside of their major, and studying abroad. For some non-persisting students, restricted participation in activities they believe strongly contribute to their overall college experience was a factor in their decision to choose majors.

Disinterest in Engineering Prerequisite Coursework

Many students could not see the purpose of the required math, science, and engineering fundamental coursework they needed to take as part of pursuing an engineering major. Persisting students see these requirements as necessary and important, and as a result, they may feel that they are worth the effort:

I dislike the fact that you have to go through quite a bit of fundamental classes or principles... [but they're] definitely important and I know that there's no way that I can skip past them (Persister, Structured Interview 2).

In contrast, many non-persisting students were frustrated with prerequisite courses that were seemingly irrelevant to their interests:

Even though I knew my basic level classes might not be as interesting as upper-level [classes]...I was like, "Oh well, here's what I have to get through to be an engineer, you know, check it off, check it off, check it off," whereas when I looked at the Bio classes, I was like, "Wow, that looks really interesting" (BS Non-persister, Ethnographic 1).

And from what I saw of engineering...it seemed like there was a lot of cool stuff but also a lot of stuff that isn't quite as fun. There's a lot of really interesting things that go on with it, also a lot work that isn't stimulating (BS Non-persister, Exit Interview).

I didn't know why I was learning about circuits. I'm going to be a [Engineering Management] major, so you [should] have some kind of technical background so you don't seem dumb when you're around people that you're working with. Maybe? I don't know (BA Non-persister, Exit Interview).

Although non-persisters knew they were interested in several classes within their major, many of these classes required that they fulfill prerequisites they were uninterested in taking. For non-persisters, this disinterest led them to rethink whether the engineering major they selected was appropriate for their academic goals. Furthermore, some non-persisters lacked the patience to take prerequisite courses in order to take the courses of interest to them.

In some cases, students felt that the math and science fundamental coursework prevented them from engaging in "real" engineering work. As a result, after finishing engineering prerequisite courses in the first year, they were still unaware of the differences between types of engineering majors:

I feel like because I have to take these fundamentals and because you have to take the fundamentals before actually getting into the engineering, I can't possibly know what kinds of engineering I'd like because I was never introduced to them (BS Non-persister, Ethnographic 1).

Another student, who enjoyed a hands-on mechanical engineering design course, recommended that there be other classes aimed towards freshmen that wish to learn about engineering fields:

I would advise them [the engineering department] to give more classes...that show what its like to be an engineer, because I'm sure there are many people out there who are interested in that kind of subject but are turned off because they don't know what it is [they] do. There are less mathematical skills [used] in engineering, and some people who say they don't like math decide well, then I can't be an engineer...When you come into mechanical engineering, you don't know what you're going to do, and a little more idea of what you could do would be great. (BS Non-persister, Ethnographic 1).

SPri does offer introductory seminars aimed towards introducing freshmen to engineering topics. These seminars are often offered by a specific department to provide an overview of research topics and industries relevant to the major. However, particularly because not all students have experiences with engineering prior to matriculation, they may not be aware of distinctions between majors and may need more information to determine which major is most appropriate for their interests. Thus, a seminar that introduces not just a single department but also a variety of different engineering majors could be especially beneficial to students.

SPri gives incoming undergraduate students an opportunity to learn more about engineering through a summer program that takes place four week before the freshman orientation. The Engineering Summer Program introduces a broad range of engineering disciplines to students while giving them a chance to take meet other prospective engineering students and develop a social network within the school of engineering. One out of twelve non-persisting students participated in the summer academy while six of the 26 persisting students interviewed for the first structured interview participated. Persisting students' found the summer academy to be worthwhile for gaining knowledge of differences between engineering majors, introducing them to engineering faculty, and engaging in engineering coursework early. Summer programs that may give engineering students a head start appear to be useful for students to realize which engineering majors are most interesting to them.

Curriculum overload and disinterest with prerequisites may be strongly connected. Many of the courses that are required of engineering students during their first two years are prerequisite classes outside of their department. Combined, these two factors contribute to a lack of academic flexibility and possible overall disengagement with engineering for non-persisting students. Both persisting and non-persisting students experience curriculum overload and disinterest with prerequisites, but many of the non-persisting students in this study did not feel that prerequisites were worthwhile to their academic goals. However, the majority of non-persisting students switched to majors that were of genuine interest to them. Factors that influenced non-persisting students to choose their new major are discussed in the following section.

(Re)discovering a Passion

Despite their eventual non-persistence in an engineering major, non-persisting students were passionate about the idea of majoring in engineering upon matriculation. For several non-persisters, engineering was a clear choice based on their prior experiences in high school:

I never imagined myself not doing engineering as high school ended...my entire background seemed to push towards engineering...I wouldn't imagine anything other than engineering at that point (BS Non-persister, Exit Interview).

In high school I really loved math and I really loved physics... and I hadn't been exposed to some other things that I found out later that I enjoyed more. So, I felt there's no way I'm going to find something else that I'd really become passionate about (BS Non-persister, Exit Interview).

Before coming to [SPri] I really loved computers and I still do. I learned how to program computers before high school, I've been programming forever and really liked it a lot and really liked, as I still do, the idea of using technology to make an impact in society...And because computers were what I knew the most about, I thought, okay, computer science is definitely the place to do that (BS Non-persister, Exit Interview).

Notably, these three non-persisters ended up pursuing a multi-disciplinary major outside of engineering that combines computer science with cognitive psychology and philosophy.

Although many non-persisting students were sure they would pursue an engineering major when they started college, they found other majors that they even more passionate about. After reflecting on their engineering and non-engineering courses, many students felt that switching majors was ultimately a good decision. For example, one student found that he loved to analyze court cases:

It was my preliminary writing and rhetoric class. I basically was doing an analysis of a court case, and I just really enjoyed all of the research I did for it and all of the writing, so much that I really realized that I loved this in a way that I hadn't loved engineering, I had just enjoyed it. And I realized that's really where I wanted to go with my life (BS Non-persister, Exit Interview).

Another non-persisting student, who struggled with engineering coursework, discovered an interest in Linguistics:

I left engineering because I could either stay and fight against my actual skill, and eventually be put out because I failed out of [SPri] ...I decided to temporarily go in a different direction. But in going to a different direction, I found that there were classes that better utilized my skills and brought out different interests, so I haven't gone back to engineering...I'm liking what I'm learning and interested in what I'm learning more so I think that's a definite plus (BA Non-persister, Exit Interview).

Finally, one persisting student realized that the courses he had especially liked were ones within his new major:

Looking back, I realized a lot of the classes that I enjoyed the most – they, are also prerequisites for [Multidisciplinary Systems Major]. So, I thought, "Yeah, this is...I'm

not just being reactionary. This was definitely a wise choice,” and I’m still really happy with that (BA Non-persister, Exit Interview).

For these students, their non-persistence may have been for the better, as they were able to explore majors they were truly interested in and motivated to learn more about.

The Power of Academic Advisors

Professors appeared to play an influential role in helping students switch to a new major. Six out of twelve non-persisting students who had an exit interview discussed how an academic advisor affected their decision to non-persist. For example, one student spoke about her supportive advisor:

The most important moment for switching directions was my advisor, meeting my advisor and starting to realize the resources that I had on campus to sort of get me through my experience here at [SPri]...She helped me understand that [SPri] wouldn’t be disappointed just because I said I was going to be chemical engineering and that might not be the case...She helped my esteem and she sort of helped me search for courses that fulfilled a passion (BA Non-persister, Exit Interview).

Some professors within non-persisting students’ new departments worked closely with the student by answering their questions about the major and helping them determine course requirements. For one student, a physics advisor helped him realize that he could still pursue a master’s degree in computer science after completing an undergraduate degree in physics. Some professors taught engaging non-engineering courses that the students particularly enjoyed, and their professors ended up becoming their academic advisors.

Supportive professors were highly valued both inside and outside of engineering departments. When asked, “Are there any aspects of your education at [SPri] that you find particularly helpful in achieving your academic goals?”, resources and community within the engineering department were most commonly mentioned in both persisters and non-persisters’ responses. The role that professors can play in influencing students’ satisfaction within an engineering major should not be understated, and professors should continue to engage their students by supporting them in achieving their academic goals.

Discussion

Analysis of academic transcripts and interview data of students during their first two years of college revealed several insights into non-persistence in engineering majors. By their engineering course-taking patterns (particular types of courses and number of units) and grades during their first year at SPri, persisting and non-persisting students are virtually indistinguishable from one another. However, by the end of the first year, BS NPs have taken significantly ($p < .05$) fewer engineering courses than persisters. We also expect this difference to be true of persisters and BA NPs although it is likely not evident here due to the small number of BA NPs in our sample. We also note that at the end of the freshman year, persister and non-persister are equally confident in their math abilities and science abilities. The one

distinguishing indicator between the persisters and non-persisters at the end of their first year of college is that non-persisters are less likely to report that they intend to complete an engineering major. This finding is generally consistent with the findings of Eris, et. al.¹⁰, though the differences between the two SPri groups (persisters and non-persisters) in intention to major in engineering only begins to emerge at the end of freshman year.

Differences between the persister group and the non-persister group (both BS NP and BA NP) become apparent beginning in the students' first quarter of their sophomore year (Q4). The number of engineering courses units being taking by persisters is significantly greater than both non-persister groups (both BS NP and BA NP). In addition, the difference in intention to complete a major in engineering becomes greater between the persister and non-persister groups over the course of the sophomore year.

Also noteworthy is the finding that non-persisters who eventually pursue a BS (BS NPs) in a non-engineering field are virtually indistinguishable from the non-persisters who eventually pursue a BA (BA NPs) in a non-engineering field based on the overall number of engineering units taken during their first and second years of college. However, there is a difference (though statistically not significant) between BS NPs and BA NPs, with BS NPs taking more engineering foundations and depth courses than BA NPs during all three quarters of the sophomore year. Might BA NPs be "drifting away" from engineering more quickly than BS NPs? Are BS NPs still exploring the possibility of an engineering major further into their second year? Is there an opportunity to intervene with those still on the fence with engineering in the engineering foundation courses taken in Q4 and Q5? How might sophomore advising come into play? And is there critical thinking and reflection about choosing a "major" that occurs during the summer between freshman and sophomore years that could be better supported?

Consistent with Seymour and Hewitt³, our results suggest that ability (as indicated by grades and confidence) in engineering coursework may not play a significant role in decisions of SPri students to non-persist but that differences between the two groups lie in their strategies and approaches for coping with the common challenges and situations they encounter. Non-persisters and persisters experienced similar concerns about academic coursework including a sense of curriculum overload and disinterest in prerequisite courses. For persisters, however, there was a greater sense of or patience with these prerequisite courses in math and science as building towards real engineering courses. Non-persisters may experience dissatisfaction with engineering and decide to leave before they can fully engage in engineering-specific classes within their major¹⁸.

A concern brought up by non-persisters was their inability to gain a broad prospective on the differences between engineering majors. Because they were engaged in math and science requirements during their first year, they felt they did not have a chance to learn more about specific majors and determine which major was most closely linked to their interests. It may be particularly useful for engineering departments to provide opportunities for students to learn more about different engineering fields before they make a final decision about their major. Summer programs can be a step in the right direction, but offering chances for more students to learn about engineering disciplines during the academic year, specifically in the first year, may help students make a more informed decision when choosing their major. Furthermore, courses

that provide a broad perspective of differences between engineering majors rather than overviews of a particular engineering department may be particularly helpful for students to distinguish between engineering disciplines.

What we do not know from just looking at the course units is how influential the limited exposure to engineering is on individual students. Do those few units in any way help confirm whether engineering is the right (or not the right) pathway for them? Are there other courses either within or outside engineering that might influence how students think about the engineering major?

Finally, students also expressed concern over the number of units required to fulfill an engineering major. Particularly because students from SPri were able to contrast their requirements to students pursuing non-engineering degrees, many felt overwhelmed by their inability to take courses and engage in activities outside of their major. They felt that they missed opportunities to engage in enriching experiences such as studying abroad and participating in extracurricular activities. Unlike other majors, engineering students must be moving and working towards a major early on in order to ensure they fulfill their graduation requirements within four years. Frustration with prerequisites may be partly resolved by contextualizing coursework so students understand the relevance and application of what they are learning and how this might be incorporated in their future coursework.

Future work is necessary to determine whether the observations of the experiences of engineering persisters and non-persisters during their first two years of college studies elicited from SPri are consistent across the other three institutions involved in the APS longitudinal study and across engineering programs more broadly in the United States. This study provides preliminary work to enable others to pursue similar analyses on non-persistence in engineering programs.

Conclusion

Persisters and non-persisters at SPri look alike in the number of engineering course units they take during their first year of college. However, it appears that non-persistence was affected more by a general dissatisfaction with engineering requirements than by low grades or decreased confidence in engineering coursework. In some situations, students simply discovered that another major was a better personal fit for their interests than engineering. Retention may be increased by enabling students to gain knowledge of engineering disciplines early on in their undergraduate careers and by helping students understand the relevance of prerequisite coursework. The critical period of transition between the end of the freshman year into the sophomore year is a particularly opportune time to intervene. Future work can determine whether these trends are consistent across institutions and programmatic structures and investigate how non-persistence may be affected by proposed interventions such as increasing advising and mentoring interactions, first year experiences focused on introducing students to the range of engineering fields, and providing resources related to long term course planning and strategies to address curriculum overload.

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