

AC 2010-1467: TOWARD A BETTER UNDERSTANDING OF ACADEMIC AND SOCIAL INTEGRATION: A QUALITATIVE STUDY OF FACTORS RELATED TO PERSISTENCE IN ENGINEERING

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Toward a Better Understanding of Academic and Social Integration: A Qualitative Study of Factors Related to Persistence in Engineering

Abstract

In general, the challenge to produce more engineers in the United States can be understood as two-pronged: (a) recruiting students to the field of engineering; and (b) retaining students in the discipline. There have been considerable efforts to recruit additional students to engineering which have yielded modest results. However, the increase in enrollment has not coincided with an increase in engineering graduates. Therefore the departure of students from the discipline remains an issue. Using a recently proposed model of engineer retention by Veenstra et al., this paper examines the first-year experience to better understand the issue of retention in engineering focusing specifically on the broad variables of academic and social integration.

Using semi-structured interviews, I asked questions relating to students' expectations of the first year, motivation to pursue an engineering degree, satisfaction with the first year and academic and social interactions. The students in the study were first-year students who were completing the second semester of a two-semester introductory engineering sequence. The sample consisted of ten students.

The findings highlight key factors of academic and social integration as perceived by the participants. I argue that within an academic discipline, the lines between academic and social integration in the student experience are blurred such that a general term such as "sense of belonging" is more appropriate. Two main themes emerged from the data with regards to students' sense of belonging: (a) the impact of participants' connectivity with peers, faculty and the College of Engineering; and (b) the extent of participants' socialization to the engineering profession. The primary contribution of these findings is a better understanding of the engineering student experience that suggests a revision to Veenstra et al.'s Model of Engineering Student Retention. In addition, these findings extend previous recommendations related to first-year engineering instructional and student support practices aiming to improve retention rates. Finally the results suggest specific avenues for further research into the impact of these factors on retention rates and the viability of the proposed model.

Introduction

In the United States, there is growing concern among leaders in government, education and industry about the production of scientists and engineers. The concern centers on the widening gap between the United States and other developed nations in the production of workers in science, technology, engineering, and mathematics (STEM) fields.^{1,2} Because of the influence of scientific and technological innovation on economic prosperity and national security, leaders at all levels acknowledge the need to address the problem.³

In engineering, enrollment and retention rates have fluctuated over the past two decades resulting in a net decline in the production of engineering graduates.⁴ Although recent work suggests that the rate of persistence among undergraduate engineers is no different than other fields⁵, engineering is one of the few fields with a net attrition of students as a cohort moves

through college.^{6,7,8} Engineering has some of the highest attrition rates as approximately 30-40 percent of the entering cohort departed from these fields.^{9,10} Furthermore, engineering has the lowest rate of migration into the major from other majors.

The net attrition appears to be the result of both a high rate of attrition and a low rate of migration. Attracting additional students to the field of engineering remains a challenging issue given the credit hours required and the prerequisites necessary for students entering the discipline. These issues are worth further consideration. However, given the obstacles to attracting more students to engineering and the persistently high rates of attrition, a continued focus on increasing retention rates within engineering remains important. This paper focuses on improving our understanding of student persistence within the field of engineering.

Background

In engineering as well as other STEM fields, retention research has been heavily shaped by the work of Seymour and Hewitt.¹¹ Seymour and Hewitt found that students who leave STEM fields do not differ significantly on measures of performance, motivation, or study-related behavior. In interviews with leavers about departing STEM, the students most often cite frustration with the experience in the discipline including criticism of the quality of teaching, advising, and curriculum design. Further students expressed frustration with uninteresting and content-laden courses that led to an increasingly negative perception of STEM careers and an overall disinterest in the subject matter. As a result, much of the focus in engineering education has focused on developing engaging classroom experiences through curricular and pedagogical innovations.^{12,13,14,15} This focus has served the dual purpose of addressing the retention issue while simultaneously improving student learning and professional preparation.

Despite these ongoing efforts to revamp curricular and pedagogical practices in undergraduate engineering, the production of engineers remains an issue. The field of engineering continues to attract and retain too few students.¹⁶ Therefore research efforts should extend beyond the classroom to include other elements of the student experience. In general, there is evidence for the impact of non-classroom experiences on learning, satisfaction and student success.¹⁷ Thus it seems reasonable to explore the issue of departure from engineering more holistically.

One way to conceptualize the engineering student experience is through a recently proposed model of engineering student retention.¹⁸ This model extends the work of Tinto's¹⁹ Interactionist Theory of student departure to better describe the decision-making of engineering students related to their field of study. In general, Tinto's model suggests that pre-college characteristics (e.g., family support, pre-college academic achievement) significantly influence students' decisions to persist and graduate from college. These characteristics impact how students perceive their academic and social experiences and the extent to which they feel integrated or a sense of belonging in these spheres. Tinto's model links students' integration in these two areas to their likelihood of success and likelihood to continue in their studies.

Introduced in Tinto's work, academic integration results from experiences both in and out of the classroom that relate to a student's academic life and encourage a stronger association with the academic community. Academic integration includes a range of academic experiences

such as informal contact with faculty, success in the classroom, and participation in disciplinary research projects outside of class. Similarly social integration represents a deepening association to a social community. Social integration results from participation in opportunities that foster connections within the community such as extracurricular activities, informal conversations in the residence hall and social events.²⁰

These types of activities combine to cultivate membership in a community for the student.²¹ The degree of integration in the community impacts the student’s commitment to related goals and persistence in that domain. For example, students who participate in engineering-related events outside of class are more likely to feel connected to the community of engineers and see more value in persisting to degree completion. In addition to the structural obstacles of curriculum and pedagogy, Seymour and Hewitt noted that a lack of identification with STEM careers was an additional factor influencing students’ decisions to leave the discipline.²² This is an element that can be better understood by examining the student experience holistically.

Theoretical Framework

Veenstra et al. proposed a few minor changes to Tinto’s model to reflect the departure decision of undergraduate engineers (See Figure 1).²³ In their retention model, pre-college characteristics affect how students experience college both academically and socially. The student experience in turn impacts two broad commitments and academic success that influence a student’s decision to persist in the discipline. Thus the student experience is a critical variable and is defined by the student’s academic and social integration. Accordingly students’ academic and social integration is a key predictor of persistence in the Model of Engineering Student Retention.

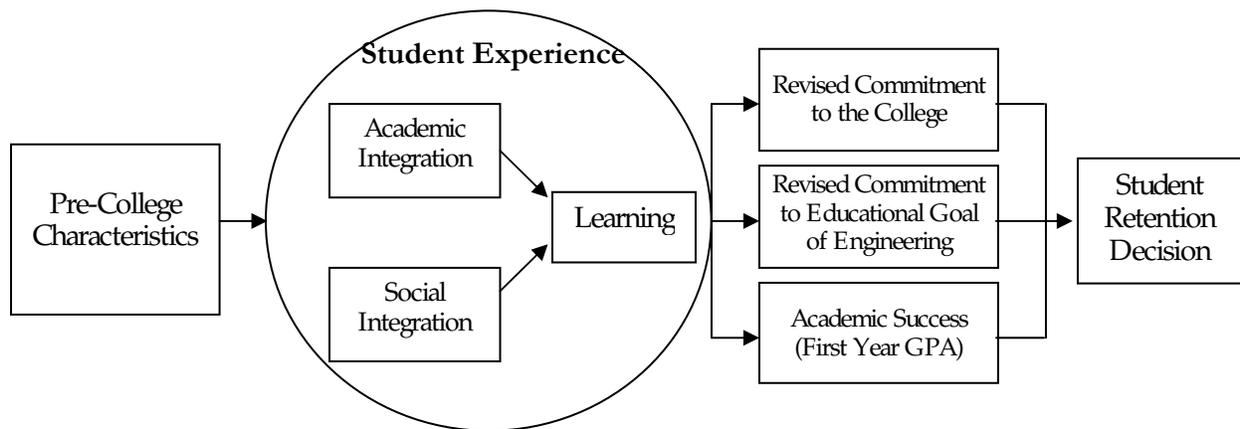


Figure 1: Veenstra et al.’s Model of Engineering Student Retention

Given the rigor of engineering, it is reasonable to assume that academic success plays a major role in determining whether a student will persist in engineering. However the data relating academic success to departure from STEM fields is mixed. Although Veenstra et al. highlight the effect of academic success on the decision to leave in their model of departure, their own data confirms previous research demonstrating no significant differences in aptitude or achievement between students who persist in engineering and students who drop-out.^{24,25, 26}

Seymour and Hewitt found that leavers and stayers did not differ significantly on measures of performance, motivation, or study-related behavior.²⁷ Surprisingly, leavers tend to be disproportionately from a pool of students who achieve academically in terms of pre-college and college performance indicators.²⁸ Thus this study does not focus on academic success, but instead attempts to better understand the other elements of the student experience i.e., academic and social integration, that influence student retention decision in engineering.

Research Questions

The study aims to address the following research questions:

1. What elements of the student experience affect first-year students' commitment to engineering?
2. What elements of the student experience affect first-year students' academic integration in engineering?
3. What elements of the student experience affect first-year students' social integration in engineering?

Methodological Framework

In this study, I chose qualitative methods to examine the experience of first-year engineering students. To understand students' tendency to persist, it is important to examine their perceptions of experiences including social involvement because these decisions are made based more on the perception of what exists as opposed to what exists.^{29,30,31} Moreover persistence decisions involve the integration of complex phenomena related to one's sense of belonging.³² This focus required the use of qualitative methods given its complexity and ill-defined nature.^{33,34,35} Finally applying a qualitative methodology will allow for the generation of rich, detailed descriptions of the academic and social integration of engineering students which can serve as a starting point for research in this area.

Sample

The participants in this study were ten first-year students in the Engineering College at a large research university. Students selected for this study were completing the second semester of the required introductory engineering design sequence in the spring of 2009. The sequence consists of two courses: (a) Fall Course (called "EGR 100" in this paper) designed to introduce students to the engineering profession and included mini-design projects, problem-solving activities and group work assignments, and (b) Spring Course (called "EGR 101" in this paper) focusing primarily on basic modeling. For the academic year 2008-2009, 272 students completed this sequence and were therefore eligible for this study.

To identify the sample, I selected a representative group of students from the course roster of 272 students and contacted them by electronic mail about participating in the study. The participants were offered 25 dollars as compensation if they agreed to be interviewed. Because an insufficient number of students responded initially, I identified additional subsets of students to contact. This process was repeated six times until the desired number of participants (ten)

responded. In total, I contacted 113 students to identify the ten participants for this study. A breakdown of the sample's characteristics and their pseudonyms are presented in Table 1.

Table 1: Characteristics of Sample

Name	Gender	GPA Fall Course	GPA Spring Course	ACT Composite
Abby	Female	3.0	1.5	19
Barb	Female	3.0	3.5	30
Cathy	Female	3.5	3.5	23
Dan	Male	4.0	3.5	23
Fred	Male	3.5	2.0	25
Heather	Female	3.5	2.5	17
John	Male	4.0	3.5	25
Kyle	Male	4.0	4.0	34
Matt	Male	4.0	4.0	28
Nate	Male	4.0	4.0	20

As a result, I was able to roughly match the sample of participants to class members in terms of grade point average (GPA) in their fall term engineering course, and ACT Composite score in relation to the institution's percentiles for entering first-year students. Spring course grades are listed above; however the semester was not completed at the time of administration. Of the first-year engineering students at the institution, only 20 percent are women. Because the retention and success of women in engineering is an important issue both at the institution and in the country,³⁶ I oversampled for women. There was no attempt made to control for race or ethnicity. However it is notable that three participants self-identified as underrepresented minorities. Table 2 compares the characteristics of the students in the targeted sample with the sample of participants in this study.

Table 2: Comparison of Sample to all First-Year Engineering Students in Introductory Course

Group	#	GPA Fall Course		GPA Spring Course		ACT Composite Scores*			% Female
		≤ 3.0	> 3.0	≤ 3.0	> 3.0	Lowest 25%	Middle 50%	Highest 25%	
All	272	14%	85%	49%	51%	13%	53%	34%	20%
Sample	10	20%	80%	30%	70%	30%	40%	30%	40%

*Entering ACT scores for the institution studied were as follows: (a) lowest 25th percentile = less than 23; (b) middle 50th percentile = 23-27; (c) highest 25th percentile = more than 27.

Interview Protocol

The interviews included a range of questions to examine the first-year experience of engineering students broadly. The interviews were semi-structured to allow for the same general questions to be asked, but allowing for flexibility in the order and precise content depending on the participants' responses.³⁷ The interviews focused on issues from the literature on retention such as academic and social integration, motivation to pursue degree, classroom experiences and faculty interactions.^{38,39,40} For example, I asked participants to describe (a) how they chose the

institution; (b) how they chose engineering; (c) their college transition, (d) their expectations for college and engineering and the extent to which they were met, and (e) how they interact with peers, faculty and the administration.

In addition, I administered a series of questions added to the protocol for a related study on the first-year introductory course sequence at the Engineering College. These questions were designed by a different research team, but incorporated into this protocol for administration purposes.

Multiple reviews of the protocol occurred. First, two members of the faculty in engineering and one educational researcher familiar with engineering research reviewed the protocol for content and offered suggestions for wording of questions that may resonate better with undergraduate engineers. In addition, two faculty members in education who have extensive experience in qualitative research methods reviewed the protocol for form related to the administration of interviews including sequence of questions, selection of probes and wording. Finally I piloted the interview with a sophomore in the College of Engineering at the same institution. As a student who had recently experienced the first-year transition into engineering, she provided feedback related to the clarity and content of the questions, and she suggested additional follow-up questions based on her experience. These three reviews helped to refine the instrument for both form and content.

Data Collection

Prior to meeting for the interview, I electronically mailed the interview questions (without probes) to each participant. Each interview was 60-75 minutes in duration. I recorded each interview in addition to taking field notes during the interview. At the conclusion of each interview session, I reviewed and elaborated on the field notes adding observations or notes for clarification. Finally, I conducted an observation of the lecture session of the spring course (EGR 101) of the introductory, two-course sequence.

Data Analysis

Each of the ten interviews was transcribed verbatim. I read through the transcripts once making initial notes about potential themes and observations in the margins. I brainstormed a list of potential themes by which the interviews could be coded. Then I returned to the transcripts and began coding the interviews using explanatory coding based on the emergent themes, relying on inferential analysis.⁴¹ Following the coding process, I grouped the ideas into themes then subcategories and then groups in a hierarchical manner. Finally I developed a matrix of key themes and revisited the data to note the presence or absence in each of the interviews. In particular, I wanted to ensure that the classification of a participant's responses was consistent across the entire interview and not just based on a small section of the coded interview. In addition, I checked to ensure that categories and subcategories accurately reflected the themes from which they emerged, rechecking coded sections for fidelity.

Results

I identified two large themes regarding academic and social integration. The first theme is students' sense of belonging. This section reports participants' sense of how they interacted with

others and in what ways they developed associations and support systems in their first year. The second major theme is socialization to the profession of engineering. This section compares participants' expectations for their engineering education including reasons for choosing the discipline with perceptions of how they are socialized into the engineering profession.

Sense of Belonging

Within the theme of sense of belonging, I identified three subcategories that influence the academic and social integration of first-year engineering students: (a) connectivity to peers; (b) connectivity to faculty; and (c) connectivity to the College of Engineering.

Connectivity to Peers

When asked about their friendships in college, students uniformly expressed interest in developing peer relationship with other engineers. However a majority of participants expressed regret for the lack of strong peer affiliations with other undergraduate engineers. All of the participants indicated that their primary social group affiliations emerged from their residence hall or from friendships before arriving at the university.

In reflecting on their lack of peer relationships in engineering, the participants were surprised that they did not have stronger bonds with other engineers. When discussing his expectations for peer interactions, Kyle expressed surprise at his inability to make friends through his classes:

I thought that I would meet a lot more people in my classes. But I haven't really met as many people in my classes. I guess in the group work especially in the engineering classes I definitely met people working in my groups. But you know sitting in a math class, or in a lecture hall, I guess I thought I would meet people but I haven't really met anyone. Everyone I've met out here has been outside class.

Kyle's sentiment was common among participants. Outside of the formal relationships formed through group work, there were few opportunities to connect with other engineers.

Six of the participants felt that they had no relationships with engineering students outside of group work. Of the few students who had engineering friends, all but one developed these relationships through unique circumstances like random residence hall assignments with other engineers, pre-college activities, or working in the engineering administrative offices. For example, Matt recognized his good fortune to connect with other engineers through his placement in Honors College housing near other engineers:

I think I got lucky because I was surrounded by a bunch of engineers. But I was talking to some friends [other engineers] who kind of felt secluded, like they had a lot of homework and the rest of [their friends] didn't. So I think maybe grouping, like engineers together, like kind of make you be around people who shared the similar experience as you would be good.

From the data, it is clear that first-year students struggle to form relationships with other engineers despite their desire to do so. Those fortunate enough to encounter engineering peers through other opportunities recognize the unique benefit.

In addition to the lack of social connectivity, one tangible concern emerged in reflections on the lack of friendships with other engineers. Most of the participants who lacked peer relationships with engineers lamented their inability to form study groups. Kyle reflected:

It would have helped sometimes to know people to study with... It would be so helpful right now if there was someone I met who I could sit down with and study with. But I haven't met anyone and so it's really me on my own trying to learn this stuff

On the other hand, Cathy, who was successful in befriending other engineering students summed up both the immediate and future benefits of these relationships to her success:

I didn't expect to meet as many [engineers] and have really good relationships with engineering students... I'm really excited about that because a lot of them are from the same major and people who are freshmen and will be here the four years together and they will always be there, whatever, for help and things like that...I like to know what other people's perspectives are... how they solved the problems or things like that... because sometimes they'll tell me how they did it and I'll be like "oh, that makes a lot of sense. I wish I would have thought of that"... it's always nice to check my work with others.... I think I work in groups a lot outside of just projects and things

Therefore successful social integration as measured by the establishment of peer groups seems to both impact the students' sense of belonging and their academic success.

Connectivity to Faculty

In terms of relating to faculty, most of the participants reported little or no interaction with faculty. Five participants reported interacting with faculty outside of class. Most of these interactions involved brief exchanges seeking clarification on concepts or homework that occurred before or after class, or via email. Only two students had more substantial conversations with faculty.

In part, the limited faculty interaction can be attributed to a lack of expectation among the participants for these types of interactions. Kyle articulated this sentiment in the following way:

I know that they have different things they're working on. They have their own projects. Also the time – it seems that they probably have a lot more going on than a high school [teacher] would. Maybe it's not as important for them to get to know students on a personal level because there are so many [students] and there is so much going on, on a college campus.

Overall most participants believed that faculty would neither have time nor want to interact with them.

Among those participants who interacted with faculty, their view of the interactions was mixed. The three who were disappointed reported that the faculty were disinterested in meeting with students. On the other hand, three participants viewed professors as willing and available resources. Their accounts directly contradict the negative perceptions reported by the other participants. Interestingly, even these students were not expecting faculty to support them in this way. Dan remarked:

I heard from so many people, "You're going to have these lecture halls with five hundred people, the teachers don't care about you." I would say the one thing is the teachers do care here... That was something I did not expect. I expected the professors to say, 'Well

the test is on Thursday, you have to know it, so just do the test”. [Instead] they are all really willing to help.

Only one participant reported interacting with faculty about non-class related issues. Fred spoke to one of his professors regarding his career interests and was pleased to have “just a common conversation” regarding his career interests. This interaction was an exception in the sample because the rest of the participants did not interact with faculty about non-course related matters.

The reports of the quality of faculty interactions are inconsistent – some are positive; some are negative. However it is clear that few participants expect faculty to be accessible to first-year students. Overall, the data suggests that students do not view faculty as resources and the few who interact with faculty tend to focus primarily on assistance with coursework.

Connectivity to the College of Engineering

A final theme emerged related to students’ sense of belonging to the College of Engineering. When reflecting on their involvement in the College, only three of the participants felt strongly associated to it. Dan articulated this relationship succinctly “I feel like right now it’s just kind of a place to take classes”. Later he expanded on the issue stating:

I kind of figured that as they [the College] don’t know if they want us to be in the College of Engineering and we don’t really know if we want to be in the College of Engineering yet, I kind of thought that there would be some stuff to get us interested in the College of Engineering, but there wouldn’t be a whole lot to do because they don’t really know—and we don’t really know what we want yet.

Dan’s response highlights the tension for first-year engineering students who are technically “pre-engineering” because they must apply for admission to the College of Engineering once they have accumulated sufficient credits in the field. Many of the participants perceived their relationships with the College of Engineering as enigmatic.

For some, like John, the small amount of time spent in the engineering building underscored their lack of connection with the College of Engineering and impacted their sense of belonging in the College of Engineering:

This is probably only like the fourth time I’ve been in the building to be completely honest [referring to attending the interview], but I’m looking forward to starting to taking classes in here and getting to know some of the professors... I wouldn’t really associate myself with the Engineering School at this point, but I’m looking forward to expanding that relationship... Actually I’m kind of interested in applying for jobs in the engineering building and kind of getting around here. Something, I don’t know, even janitorial work, but just to be in the building I think would be better and a little bit more at home.

John feels so isolated from the community that he views any opportunity, including working as a janitor, as an opportunity to be more associated with the College. Many participants expressed feeling like outsiders in the College of Engineering.

John’s experience with the College of Engineering was not unique. Four of the other participants specifically cited their lack of time spent in the Engineering building as impacting

their sense of belonging. Nate tried to address the issue head-on by spending more time in the building:

I had to actually come here myself while I don't have any courses in the engineering building at all, I've had to come here myself and just look around, just to find something that can help me have a better relationship with the College of Engineering

Despite these efforts, Nate struggled to connect. He joined a club working on solar car technology but was not adequately prepared to participate due to his minimal knowledge base. He described the experience as “down-turning” and “deprecating”.

The exceptions to this finding were Cathy, Heather and Kyle, all of whom had unique experiences. Cathy was able to enroll in an additional engineering course due to academic credits obtained in high school. As a result, her perception was considerably different: “Sometimes I feel like it consumes my life because I only have one class here – in the building – this semester and I feel like I spend all of my time here.” Cathy's additional engineering class connected her to the Engineering College through its time-intensive requirements in the computer lab for class assignments. Similarly Heather worked in the College of Engineering's administrative offices spending plenty of time in the building and interacting with members of the staff.

In a similar vein, Kyle had a unique opportunity because of his affiliation with the Honors College. He recognized the uniqueness of his situation reflecting:

I feel like I'm able to be a little bit bigger part [of the Engineering College] than most because of some things that the Honors Program has set me up with... I work in a lab downstairs... I've actually been an active part of a lot of projects down there and one of them was geared towards exposing pre-college kids to different aspects of engineering, particularly biomedical which is the field that that lab is in. So I got involved a lot in that kind of project. I don't think most kids are able to be involved in something like that.

Thomas felt that his opportunity to work in the lab, arranged by the Honors College, allowed him to connect better to the College of Engineering than his peers.

In terms of connecting with the College of Engineering, the data suggests that first-year students who lack a special opportunity in the College struggle to connect. The majority of participants spends little time in the College of Engineering, feel like outsiders because they are pre-engineering and struggle to identify appropriate opportunities with which to engage the community. The sample views this lack of engagement as indicative that the College is not actively interested in retaining them within the discipline.

Socialization to the Engineering Profession

The second major category to emerge from the themes was the impact of socializing practices on students' sense of belonging. In this section, I outline the perception of participants on the nature of the first-year engineering experience as it relates to exposing students to the engineering profession. The participants' reasons for choosing engineering are compared with the nature of the learning experience. In general, the classroom experiences and projects did not meet participants' expectations for their preferred mode of learning given the nature of the field.

Aside from general interest in mathematics and science, the participants cited a combination of four aspects of engineering that interested them: (a) hands-on nature of the field;

(b) real-world applicability of the field; (c) problem-solving nature of the field; and (d) commonplace use of working in teams. I summarized the responses from the participants in Table 3 below:

Table 3: Reason for Choosing Engineering

Participant	Hands-On Work	Real-World Application	Problem Solving	Work in Teams
Abby	+	+	+	0
Barb	+	+	+	+
Cathy	+	+	+	+
Dan	0	+	+	0
Fred	+	+	+	+
Heather	+	+	+	0
John	+	+	+	+
Kyle	+	+	+	0
Matt	+	+	+	0
Nate	+	+	+	0

+ = cited the reason; 0 = did not cite the reason

In general, the majority of participants cited engineering as an area of study that involved hands-on work and problem solving to address real-world problems. The participants commented that they “really enjoy design and engineering”, “couldn’t sit behind a desk for forty hours a week”, and sought a “hands-on” major. All of the participants had a vision of what the engineering profession would be like and therefore how they would be educated for the field.

Unfortunately all but two of the participants were dissatisfied with their first-year experience in terms of the educational experience. Although the introductory design sequence was meant to expose students to the profession and prepare students for upper-level courses, the majority of participants criticized the courses, especially the first semester.

The vast majority of the participants expressed excitement about studying engineering; however the introductory sequence failed to build upon that enthusiasm. As John described:

I was hoping to just get to dive in you know like... using the labs and stuff around here, getting to work on stuff, and if I could do that I would do that year round if I could, just to get to dive into the juicy, the complex stuff, the stuff that really makes you think and makes you want to talk to your professors and learn more about the topic. Whereas it was kind of almost like building up your hopes, you’re going 0 - 60 really fast and then all of a sudden you’re like “this is going to take me four years – brakes!” You know it’s like slow down. I don’t know where it’s like it kind of gets your hopes down. You’re getting all pumped up, you know “I’m ready, let’s do this, I’m ready to take 20 credits a semester if I could just be in these labs just doing stuff and learning about thermodynamics and all of that other cool stuff to me.”

This excitement seemed to be diminished by some of the early classroom experiences. All but two of the participants reported perceptions similar to Dan who recounted that:

The projects that we do were, like I said earlier, kind of mundane, seemed like busy work, they didn’t have anything to do with what brought us into the engineering. They

didn't really have anything to do with engineering... I mean, even like walking down here [in engineering building] I was seeing people in a lab doing stuff. I don't know if that's for a project or something, but that seems like it would be kind of cool... Someday I'll get out of the boring classes and get to do something actually interesting.

The image of Dan walking the hallways and seeing what he hopes to be able to do conveys this sense that he is on the outside looking in on a community of practitioners he wants to join, but is currently prohibited. The combination of non-engineering pre-requisites and the lack of authentic engineering experiences in the introductory sequence served to diminish the participants' enthusiasm for the field of engineering.

The first-year experience even caused some students to reconsider their choice of engineering. John reflected:

I've seriously considered not being an engineer before because of the classes. Because I've thought, "Man, these classes are so boring. This is what the whole Engineering School is going to be like." And I'm not expected school to be like you go in there and there is a huge party or something. Just something a little more interesting. And I don't know—we've talked about that with my friends. We've kind of talked before—maybe they make them this way as a weed-out class.

These comments are particularly concerning because the introductory sequence is not meant to "weed out" students, but instead attract and retain them.

In discussing the shortcomings of the courses, the participants seemed aware of their limitations as inexperienced engineers, but expressed a strong interest in more practical and applicable experiences. The majority of the participants enjoyed the second semester which involved an introduction to computer-based modeling more than the first semester design course which involved hands-on projects deemed inauthentic by the participants. Nate summed up these sentiments in the following way:

I'm looking for an experience. And just a little experience... something as simple as [circuit boards], just that hands-on experience. For any freshman interested in engineering just to have an experience working, doing something based on the field in which they are interested, I think will make a big difference.

Nate captures the general sense that emerged from the interviews in terms of socializing new students to the engineering profession. The participants report starting their coursework excited to engage in engineering education and learn things about which they are passionate. They expressed a keen interest to engage in real-world projects and quickly begin to learn through hands-on experiences. Unfortunately it appears that the introductory engineering courses may be quelling this enthusiasm.

Limitations

As with all qualitative research, the issue of generalizability arises due to the limited sampling and representation of the population.^{42,43} This limitation is important for those responsible for developing policy or programmatic decisions based on this research. This small group of engineers does not suffice as a representative sample for making informed decisions about all engineers. The sample, institution and other factors should be considered to evaluate the transferability of the findings to other settings.

Second, the sample may be biased due the type of people who would agree to participate in a study like this. Although all attempts were made to select a diverse sample representative of the population at the institution, it is possible that the mode of contacting participants may bias the sample. For example, perhaps students from lower socioeconomic backgrounds may be more likely to participate because of the cash incentive provided to participants. Further the use of electronic mail to contact students limits the sample to those in the population who read these electronic communications. Biases such as these could impact the results.

With any interview, it is difficult to establish a suitable rapport with the participants especially when only meeting once.⁴⁴ Every attempt was made to make the situation non-threatening and comfortable for the participants (e.g., assured anonymity, dressed casually, engaged in light conversation before interview, etc.); however there is no way to control for this limitation. Students may be influenced by the demeanor of the interviewer in a way that may bias the results.

Finally in qualitative research, the bias of the researcher is evident in the analysis.⁴⁵ As the researcher, I bring my own set of assumptions and biases to this study that may impact my interpretation of the results. By engaging in multiple rounds of coding, I attempted to review the data anew; however it is not reasonable to suggest that the analysis is purely objective.

Discussion

In the discussion section, I will review the key findings and relate those findings to previous research. In addition, I will outline some implications of the study including a reconceptualization of the theoretical framework used in the study.

First, the participants indicated areas in which first-year engineering students struggle to develop a general sense of belonging. I organized these themes into three categories related to how students attempt to connect to the College of Engineering: (a) connectivity with peers; (b) connectivity with faculty; and (c) connectivity with the College.

The participants in this study struggled to identify socially with the College of Engineering fueled by their (a) lack of peer relationships within the College, (b) limited time in the engineering building, (c) lack of meaningful interactions with faculty, and (d) inability or unwillingness to identify as members of the community because they had not been formally admitted to the College. These factors suggest that first-year engineering students are not integrating into the community effectively which may negatively affect retention rates.^{46, 47}

These findings are important because they suggest that non-curricular interventions may significantly influence students' sense of integration and, in turn, persistence in the discipline. Typically classroom interventions have been considered most critical to improving persistence within the discipline.^{48, 49} However, the elements of connectivity identified in this study represent outcomes that engineering educators can target with out-of-classroom initiatives. For example, additional efforts to foster peer group development through community programming among first-year engineers may address some of these issues. Some potential interventions range from cluster-group scheduling of courses to living-learning communities tied to the engineering

department. These types of interventions would address concerns about connection to peers and socialization to the College simultaneously.

Another important non-classroom finding is the effect of admitting students as “pre-engineers.” Institutions concerned about retention will want to consider how they label and incorporate first-year students into their colleges as the classification seems to affect students’ ability to integrate into the community. One option would be to consider all entering first-year students as declared engineering majors who are subject to review at the end of the first or second year for adequate progress. This may diminish the alienation felt by students classified as “pre-engineering.” Alternatively, colleges of engineering may want to consider structural and support changes to the first-year experience whereby students feel an improved sense of connection to the engineering discipline such as targeting first-year students for marquee engineering events or, as suggested by the participants of this study, even just scheduling first-year courses in the engineering building.

This process of integration is made more challenging by the lack of faculty-student interaction. Faculty play a critical role in academic and social integration by encouraging students to become full members of the community and developing their sense of belonging within it.^{50,51,52} Tinto identified students’ interaction with faculty as the most influential factor in promoting retention.⁵³ In this study the participants did not expect to interact significantly with faculty, especially with regards to non-course issues. The issue is exacerbated by the size of the institution. Because it is so large, the onus is normally on the students to initiate relationships with the faculty. With no expectation for these interactions, the lack of student-faculty interaction among first-year engineering students is evident and may contribute to the retention problems in engineering. Colleges of Engineering should consider ways to promote faculty initiative in developing relationships with undergraduates, especially first-year students who are at the greatest risk of leaving.⁵⁴

In addition to struggling to connect, the participants reported a lack of socialization experiences to the profession of engineering. The students entered engineering with an interest in hands-on, problem-solving experiences with real-world applications, but their experiences did not satisfy these interests. For example, the participants reported dissatisfaction with the introductory course sequence in engineering for its lack of hands-on, real world and applicable learning experiences. In other words, the courses lacked what the participants would consider authentic engineering experiences. The group projects in EGR 100 did not sufficiently approximate the engineering profession. The strong preference for the mathematical modeling in EGR 101 over the design projects of EGR 100 confirmed the primacy of learning applicable skills for the first-year engineering students. This criticism of the curriculum is consistent with previous research on why students leave the STEM fields.⁵⁵

These findings reinforce the need to continue reform efforts in curriculum development. To address students’ expectations, faculty and administrators need to continue efforts to bring more hands-on and practical elements into the classroom. Progress in the area of curriculum development for engineering is encouraging and on-going (see Sheppard et al⁵⁶) and can be helpful in shifting away from transmission-based lecturing. Further other research such as the work of Johnson and Smith suggest that with appropriate scaffolding through class exercises, discussions, and well-calibrated milestones, instructors can facilitate credible, hands-on, student-

driven projects.⁵⁷ The findings of this study suggest that these types of experiences are important for socializing students to the engineering profession and highlighting the fit between student interest and the scope of the major.

Although some of these findings related to classroom experiences may not be surprising, taken in context with the other results, the findings suggest that curricular interventions could benefit from being conceptualized more broadly as described in research on communities of practice.⁵⁸ Members of a community of practice emphasize learning through doing, and learning from each other while participating in authentic tasks. In communities of practice, there is an underlying commitment to socialize students into the professions. Students with better awareness of the profession can refine and make better decisions regarding their commitment to learning. Thus attempts to embed curricular innovations in a more holistic and socialized schema may yield greater benefits in terms of integration and ultimately retention. In other words, engineering colleges could improve retention efforts by making classroom modifications as part of a broader, more holistic culture change intending to socialize students to a community of practice. Thus implementing improved pedagogical techniques may be insufficient to address the need for socializing experiences among these students. These changes should be a part of a more general thrust to induct students to the culture of professional engineering consisting of experiences in and out of the classroom.

In conclusion, the results of this study suggest a reconceptualization of Veenstra et al.'s Model of Engineering Student Retention.⁵⁹ First the results of this study indicate that it is difficult to distinguish between academic and social integration for engineering students. For example, the participants spoke extensively about the inability to establish friendships with other engineers. The lack of peer group hampered their ability to identify a study group thus affecting their academic success. Therefore the identification of a peer group impacts students both academically and socially. In other words, because the social group studied is defined by an academic discipline, the typical lines between academic and social integration are blurred.

Second the themes emerging from these interviews intimate specific components of the student experience: (a) connectivity to engineering; and (b) socialization to the engineering profession. Therefore I propose a revised understanding of the student experience in the Veenstra et al. model⁶⁰ that reflects the findings of this study in which I define the student experience as a function of a student's sense of belonging instead of academic and social integration (see Figure 2).

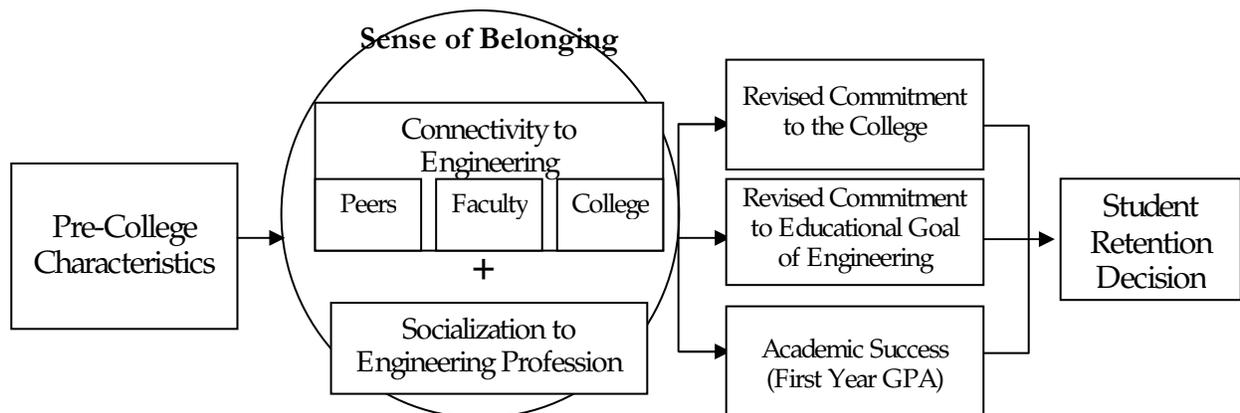


Figure 2: Reconceptualization of Student Experience as Sense of Belonging

In this model, connectivity relates directly to interactions described by Tinto⁶¹ as promoting integration. There are three key components of connectivity for engineering students enumerated by participants in this study: (a) connectivity to engineering peers; (b) connectivity to engineering faculty; and (c) connectivity to the engineering college. These three aspects of connectivity reflect the degree to which a student has developed a network of relationships within the engineering community that in turn promote a strong association to the discipline.

The socialization to the engineering profession emerges from the idea of fit between the individual's interests and the norms of the profession. As discussed previously, students enter the discipline with a set of assumptions for how the norms of the profession align with their interests. Student experiences that include specific practices that correspond to students' expectations encourage a greater sense of belonging in the discipline and willingness to persist. For example, participants in this study cited hands-on, real-world experiences that require problem-solving as the main attractive element of engineering. If their educational experiences underscore these elements of the profession, students will be encouraged by the degree of fit between their interests and the nature of engineering. Further the exposure to professional life helps to initiate students into a community of practice thus strengthening their association with the discipline.⁶² Both factors appear to contribute to a student's sense of belonging and therefore influence their likelihood to persist.

Further research is necessary to investigate the generalizability of the proposed framework. This qualitative study enabled a deeper investigation into the nature of academic and social integration in the preparation of engineers. The findings from this study provide a better understanding of the phenomena of academic and social integration for first-year engineers as it relates to disciplinary retention enabling a revision to the Model of Engineering Student Retention. However the model will need to be tested in future studies to establish its validity and to further refine its components.

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