European Journal of Engineering Education

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/ceee20

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To cite this article: Mahati Kopparla, Trang T. Nguyen & Steven Woltering (2022) Maps of meaning: journeys of first year engineering students, European Journal of Engineering Education, 47:6, 930-949, DOI: 10.1080/03043797.2022.2037522

To link to this article: https://doi.org/10.1080/03043797.2022.2037522

Published online: 02 Mar 2022.

EUROPEAN JOURNAL OF ENGINEERING EDUCATION
2022, VOL. 47, NO. 6, 930–949
https://doi.org/10.1080/03043797.2022.2037522

Maps of meaning: journeys of first year engineering students

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ABSTRACT

Undergraduate STEM retention has been a longstanding concern. Specifically, majors such as engineering have experienced a high dropout rate consistently in the past several decades. This study is aimed at understanding factors contributing to making the engineering major challenging, and individual factors that help first-year engineering students persevere in the major. Eight first-year engineering students participated in the study by completing an illustrated road map sketch of their first-year experiences and a semi-structured interview. All participants considered the engineering major challenging due to the amount of time and effort required to be successful in the courses. Being academically underprepared for first-year courses was a drawback, but only some participants were discouraged by the academic challenges. Most importantly, students' perception of academic and social fit within the major influenced their self-efficacy, help-seeking behaviour, and intent to persist.

ARTICLE HISTORY
Received 27 August 2021
Accepted 30 January 2022

KEYWORDS
Engineering retention; STEM; narrative analysis; persistance; engineering education

Science, Technology, Engineering and Mathematics (STEM) education is often associated globally with development of human capital and economic growth (Takeuchi et al. 2020). Poor retention rates in undergraduate engineering majors are often problematised with popular references such as 'leaky pipeline' assuming a restricted path towards engineering careers and ignoring the nuances of individual experiences in their career decisions (Petray et al. 2019). The generic efforts towards developing more and more rigorous academic programs to build human capital may often overlook individual needs, interests and motivations. Particularly, Cannady, Greenwald, and Harris (2014) explained:

> For example, it is not a story of [problems in the education system] to say, 'I stopped pursuing STEM in high school, even though I took calculus, because I decided I wanted to be a musician'. But it *is* a story of problems in the system to say, 'I stopped pursuing STEM in high school, even though I took calculus, because my teacher told me that girls can't do science'. From the pipeline framework, these are indistinguishable; they are both simply leaks. (457, emphasis original)

Discarding the notion of engineering education solely as an academic pursuit towards economic stability, there is a need to refocus efforts towards understanding individual needs and creating a conducive environment for students aspiring to be engineers (Litchfield and Javernick-Will 2015). By viewing engineering students as individuals with diverse interests, self-efficacy beliefs, and expectations from the major, we can better understand the undergraduate retention problem and move towards realistic solutions (Patrick and Prybutok 2018). Towards this end, the current study adds to the existing literature (Boone and Kirn 2016; Concannon et al. 2019; Myer and Marx 2014) and explores the lived experiences of first-year engineers. Focusing on their journey into the major

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and through the first year of an undergraduate degree, the following research questions will guide this study:

1. How do first-year engineering students characterise their first year of undergraduate degree?
2. How do specific individual characteristics, academic or non-academic, help or hinder engineering first-year students persevere in the program?

Literature review

Recruitment and retention of engineers at the undergraduate level is considered crucial to sustain the high demand for engineers in society. Reasons for choosing engineering as a major include: skillfulness in mathematics or science, knowing an engineer, interest in problem-solving, and high school coursework exposure (Cruz and Kellam 2018). Despite the starting motivation, many qualified students are not completing their engineering degrees and transferring to other majors (Lichtenstein et al. 2010). Undergraduate engineering majors experience a high dropout rate. An overall four-year graduation rate of 33% and a six-year graduation rate of less than 60% were recorded for universities in the United States (Yoder 2012). This alarming trend has remained constant for the several decades (Tinto 2006; Student Retention and Graduation 2022) and has been a subject of constant research (Dell et al. 2018; Forsman et al. 2015; Seymour 2002; Seymour and Hewitt 1997; Pascarella and Terenzini 1980).

Traditionally, students' high school (grade levels 9–12) scores have been considered for admission into higher education, with higher scores associated with engineering majors. High school scores include (a) a school-level assessment referred to as grade point average (GPA) on a scale of 0–4 with 4 being the highest and (b) standardised assessment scores – (SAT; College Board 2022). Engineering students are more likely to receive lower grades in undergraduate courses compared to high school, due to an increased level of academic difficulty and change in grading styles (Ost 2010; Rask 2010). The initial grades received during their first undergraduate courses may significantly influence their inclination to continue or discontinue their journey as an engineering student as grades are a mechanism used to gauge their fit within the program (Stinebrickner and Stinebrickner 2012). Thus, student persistence during the first year depends not only on their academic preparation, but also their individual characteristics such as self-efficacy, interests, abilities, needs; and environmental factors such as social, cultural, institutional influence (Concannon et al. 2019; Lent, Brown, and Hackett 2002).

Students' interests and self-efficacy beliefs are intricately related. The intent to persist is influenced by their perception of the personal agency including their self-efficacy beliefs and perceived control over academic outcomes (Montano and Kasprzyk 2015). Students enter an institutional environment with certain self-efficacy beliefs because of their past experiences. Self-efficacy is majorly derived from personal accomplishment; therefore, repeated success improves self-efficacy and repeated failures lower it (Hutchison et al. 2006). Students who believe that they can control the academic outcomes are more motivated, driven to achieve, and likely to persist (Anderson, Hattie, and Hamilton 2005).

In unfamiliar contexts, sources of efficacy beliefs may shift towards peer comparisons. Specifically, engineering first-year students primarily estimated their self-efficacy or their ability to perform based on their peer performance (Hutchison-Green, Follman, and Bodner 2008). Through interactions with the institutional environment, students constantly revise their self-efficacy beliefs and adjust their goals. Further, the social and environmental expectation or pressure a student feels towards receiving the degree influenced their intent to persistence. Students in engineering reported that their positive interactions with peers, faculty and advisors impacted their decision to stay (Hsu et al. 2021; Micari and Pazos 2016). In addition, having a high-achieving peer group or high expectations from family compels students to persist (Mbuva 2011).

The choice to pursue and persist in engineering major is not always linear and is often accompanied with feelings of being 'intimidated, concerned about the relevance of engineering to their own interests, or may simply discount engineering by seeing it reductively as an asocial, overly scientific, or uncreative field' (Cruz and Kellam 2018, 575). An array of internal and external factors uniquely influences individual journeys as an engineering major. Given the complex and uncertain changes associated with transitioning to a new academic environment (Willson 2019), we identify a strong impetus to closely examine these established variables. As qualitative studies do not restrict the variables in the study, they provide a unique approach to understand and improve retention (Borrego, Douglas, and Amelink 2009). Specifically, participant narratives can highlight individual experiences that lead to their ultimate decision to stay or leave the engineering program (Case and Light 2011). In the current study, a narrative inquiry approach is used to understand experiences of engineering undergraduates and the role of these various factors contributing to either persisting or dropping out. As engineering attrition rate is significantly influenced by first-year experiences, this study will focus on a group of engineering majors in their first year of undergraduate degree.

Methods

Setting

Kingslanding University (pseudonym) is a large public university in central Texas. The college of engineering reported that six-year graduation rates were about 80%, and four-year graduation rates were about 40% (Student Retention and Graduation 2022). With multiple engineering degree options, all students were first admitted into general engineering and through the entry-to-a-major (ETAM) process, could choose their major after they completed their prerequisites.

Participants

A recruitment email was sent through the university listserv asking for volunteers to participate in a larger engineering retention study. The criteria to participate was that they must be 18 years of age and enrolled as a first-year in the college of engineering. Eight students, Ned, Benjen, Jon, Rob, Theon, Arya, Bran and Rickon (pseudonyms) volunteered to participate. All participants completed an informed consent process before participating in the study. All participants were compensated with a $15 gift card. Even though the sample size was small, participants represented diverse populations within the engineering student body. Similar to the demographics at the university level (Student Demographics 2021), the participants were predominantly male (8 participants) of which 3 were Caucasian, 2 were Asian origin, 2 were biracial. The only female participant was of Asian origin.

Data collection and analysis

To answer the research questions, a narrative inquiry approach was used. The narrative inquiry method explores 'the lived and told stories of individuals' (67; Creswell and Poth 2016). Narrative inquiry is based on the premise that human beings are natural storytellers who experience and visualise life as a story (Connelly and Clandinin 1990). In order to understand individual experiences through the first year of the engineering program, two forms of data were collected: illustrated road map sketch, and semi-structured interview.

To create an illustrated road map sketch, participants were asked to think about their journey into the engineering program and through the first year. They were provided with different coloured pens and asked them to draw an illustrated road map of their journey. The road mapping activity to study undergraduate retention was adapted from Myer and Marx (2014). Once they completed

their sketch, they explained their illustrated road map. Next, a semi-structured interview was conducted to further explore participant experiences during their first year and answer the research questions. The interview protocol is provided in Appendix. An audio recording of the interviews was made and transcribed.

The roadmap drawing was an aid for identifying the most prominent and story-worthy events in the participant narratives. The roadmap drawings were analysed through a critical visual methodology using the guiding questions (Guillemin 2004; Rose 2001):

- What is being shown? What are the components of the roadmap? How are they arranged?
- What do the different components signify?
- What relationships are established between the components of the roadmap?
- What knowledge and experiences are being deployed?
- Who or what components are excluded from this representation?
- Is this a contradictory image? (to other data or observation)

The analysis of roadmap drawing provided insights into how participants viewed themselves and their institutional environment. By constantly combing through the data from the roadmap and interview, recurring themes within the participant narratives were coded (Kellam, Gerow, and Walther 2015). Then, each of the participant's narratives was restructured to follow a chronological pattern and presented in the third person with direct quotes from the participants. Narratives were constructed starting with individual reasons to choose the engineering major and continued through their academic and social experiences during the first year of engineering. Finally, the narratives were analyzed (Polkinghorne 1995) to identify factors that were crucial in student decisions regarding their major choice.

Participant narratives

Based on the participants' interviews and road map sketches, their reported journeys through the first year were summarised individually. The individual narratives focus on story-worthy aspects of the first-year experience as perceived by the participant. The participant narratives depict how different students characterise their first year based on their background and experiences within the program. In the following sections, the word college is often used interchangeably with the university, to represent the undergraduate institution and context.

Rob

Rob came into the engineering program with a positive attitude towards his major. He had developed a high self-efficacy for hands-on exploration through his prior experiences where he worked cars and other equipment. He explained his love for problem-solving:

> I started having this want to just do problem solving, just because of computer science and stuff like that where, you know, the little short little high you get every time you solve a really hard problem. That feeling, well, that's why I choose engineering.

Rob reported that his pre-university experiences had 'kind of' prepared him for the engineering major. While he was happy with the engineering content knowledge and problem-solving skills he had acquired, he was unhappy with the non-engineering-related courses.

Rob's road map (Figure 1) showed four distinct stages during the first year which grew darker and less colourful as time passed representing the intensity of the program and hardships that students endure. He depicted first-year students as naïve fish subjected to the horrors of college. Rob depicted the beginning of college as a warm colourful time when the idea of college was exciting. Transitioning from the 'good old days', he viewed that first few weeks of the semester as the 'honeymoon

phase'. As 'classes aren't that hard in the beginning, no one is really doing anything', and this was a relatively laid-back period where Rob got acquainted with his peers and life as an undergraduate.

Rob titled the rest of the first semester as the 'shark' phase, where the professors are the sharks yelling at the first year students, 'suffer!' when they actually mean 'learn'. The second semester escalated in terms of difficulty and thus was titled 'viperfish' phase, where the professors and college in general represented the viperfish. Rob elaborated the perceived viperfish malice:

> bunch of fish in the middle [are] huddled around each other, trying to survive, get through and these viperfish are surrounding them and showing them pieces of light that you're going to make it to the end, but you won't because we [viperfish] are going to eat you before you do.

Rob's road map, which showed him as a fish navigating a dangerous college terrain, indicated an external locus of control. Further, he was not convinced that the classes were structured for student success, he questioned, 'how are we supposed to learn all this advanced physics and mathematics in 4 months? They just kind of shove it down your throat and call it weed out classes and those are really fundamental classes'. Rob had a negative attitude towards the courses he was taking, he explained:

> I don't think we're paying for classes at this point, even though they make it sound like it. The real thing we're paying for is the [Kingslanding] network we're going to have when we leave and the jobs we might get. It's the opportunity cost that we are paying.

Within the ongoing struggle at college, Rob was seeking opportunities that could help him academically. He emphasised that students should ask for help when they need it. He noted that there are a lot of good opportunities for the students to choose from. Rob, using 'food' as a metaphor for 'anything like opportunities, friends, people, decisions' noticed that 'there's food, there's really good food, there's awesome food, tasty food, best food and we really can't decide which one to get'. Rob, when faced with academic challenges not only spent more time studying but sought help from professors, supplementary instruction sessions, and peers. He was thankful that he had made 'smart friends unknowingly'.

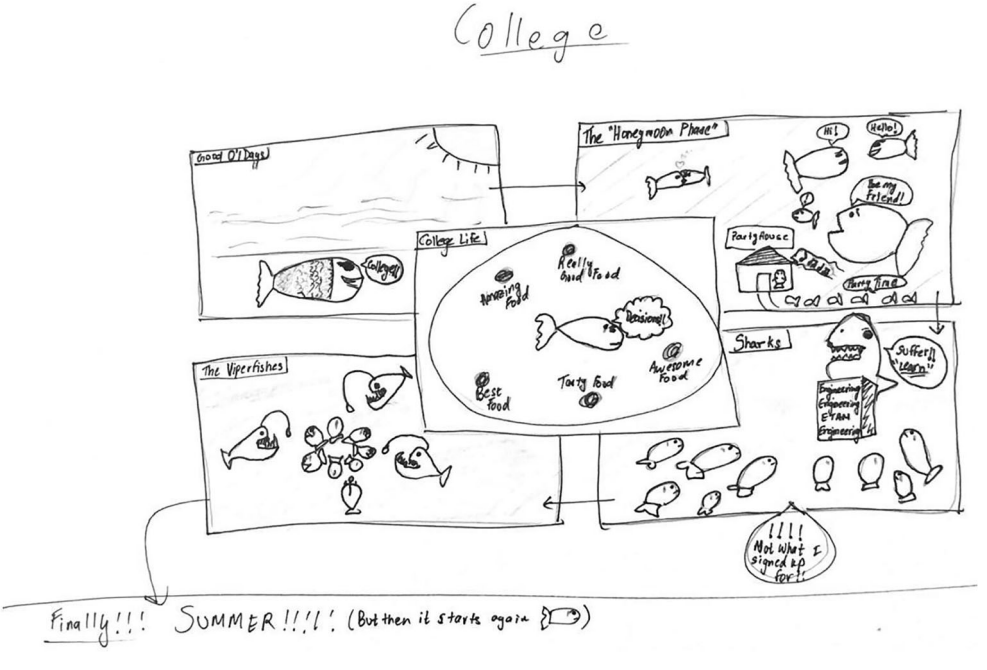

Figure 1. Road map sketch by Rob.

Arya

Arya described her family expectations as prominent factors in her career choice, 'I guess this is very stereotypical, but there's always that thing that Asians become doctors or engineers and that's same for my family … to become successful you have to be an engineer or a doctor'. Choosing engineering was easy for her as she enjoyed doing mathematics and science. In preparation to take up engineering, Arya went to a mathematics and science academy in high school. Arya was very glad that she went to the academy as she learnt about the 'connections between math and science to engineering'.

Arya, having come into the program with sufficient preparation, still considered the program challenging. In her road map (Figure 2), she separately depicted her academic and social involvement. She noticed that her social life during the two semesters was a 'huge contrast'. While she was uncomfortable being involved in the Bollywood team during the first semester, Arya felt more comfortable in the red cross during her second semester. Within red cross, finding 'the other members are really friendly and are new friends too', she found her social niche.

Arya's major of choice was biomedical engineering which had a high GPA (grade point average) cut-off for automatic admission through the ETAM (entry to a major) process. As 'most people who do biomedical engineering [are] keeping med school in mind … they're trying to have a really high GPA'. Therefore, Arya was working hard to maintain a high GPA to be able to compete with other students who were interested in the same major.

She represented in her road map that most of her courses were extremely challenging and she often needed to put-in long hours of work. If Arya was still unable to make an A, she would 'kind of [break] down and … cry'. However, by the end of the first year, she described her strategy to regulate her emotions and cope with her grade:

> I cry like every bad grade I get, so it's kind of normal for me now, so I just ended up crying … for like a couple hours and then I'm like, you know what? I have to do homework now. I watched a couple YouTube videos just to get my mood back up and then I went back [to do homework].

Arya noticed that she had devoted more time studying during her second semester. She had 'a couple of friends in each class so, if [she] was struggling with the material … then [they] would get together and study it and figure [it] out'. Arya sought out ways to help her academically and she was glad to have supportive friends and family.

Bran

Until his last year in high school, Bran wanted to go to business school. However, during a summer class, he was impressed with coding and the atmosphere of the tech world. Recognising 'that's where [his] interest was … [he] just picked [engineering] and just wanted to see where it takes [him] and if [he likes] it down the road or not'. Being able to get a well-paying job after graduating was his major reason for taking up engineering.

Bran was a high-achieving student in high school but realised that he was 'far back in the crowd' soon after he started at Kingslanding University. Symbolically, in his road map (Figure 3) Bran drew himself 'on a parachute, parachuting down into a race that has already started.' He observed that his peers at Kingslanding were exceptionally high-achieving students with a 4.3 GPA in high school or a 5.0 on Advance Placement (AP)[1] tests. The 4.3 GPA exceeded the traditional GPA scale with 4 being the highest, indicating their exceptional performance on AP courses. Not only were they out-performing him in engineering courses, but few were racing towards 'internships and opportunities ahead' even before Bran could begin the race.

Bran felt that he had acquired 'quite a bit of knowledge in high school' in terms of subject content, but lacked 'time management skills or study skills' required to fare well in college. Analyzing the reason for his academic struggles, Bran said:

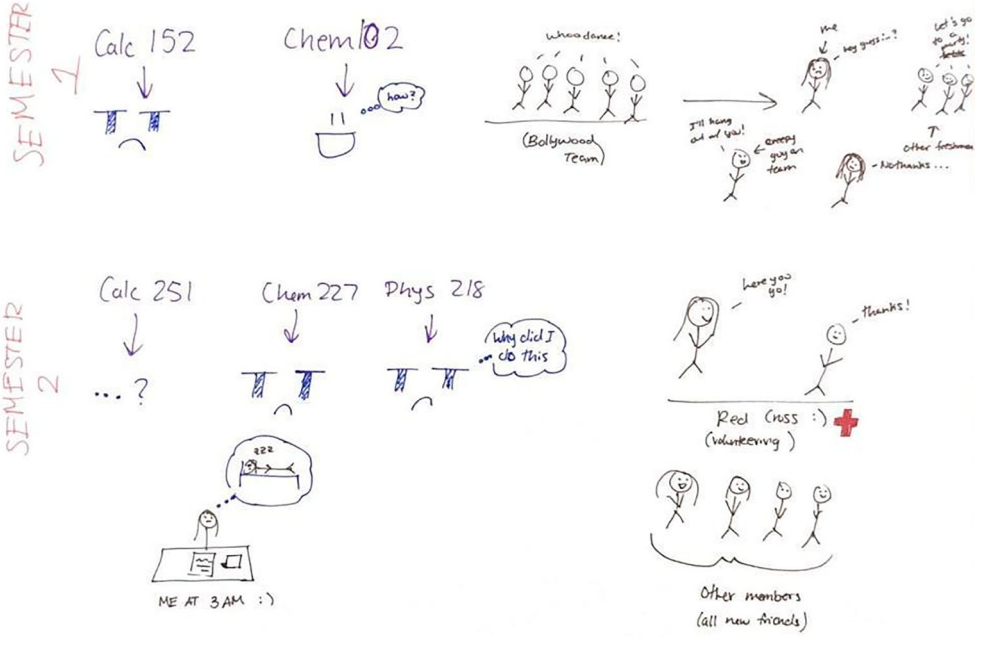

Figure 2. Road map sketch by Arya.

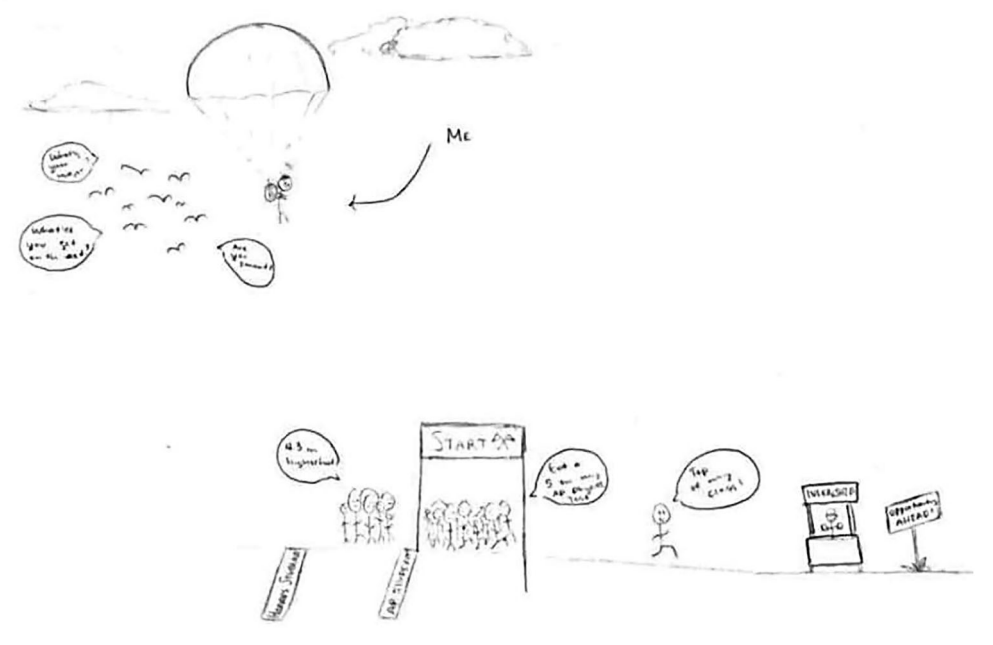

Figure 3. Road map sketch for Bran.

I feel if I really put the time in, I can do really well. I think my problem is just time management and knowing when to. Everybody could do well if they had enough time, but it's about utilizing that time when you really need it. So, I would say … I could do well.

Talking specifically about his mathematics courses, Bran reported to have 'felt pretty confident in high school about doing calculus' but was struggling in the Calculus I course at Kingslanding. Unhappy with his professor's methods of teaching, Bran relied on his high school calculus knowledge to navigate the course and 'ended up making a C when [he] should have been well in the A's'. While he partly blamed the poor teaching for his struggles, he often took it upon himself to fix the problem. He explained his panic soon after he received a C, his first thought was that his parents were going to see his grades. Then he thought of ways to fix his GPA:

> I went on the GPA calculator … for hours and I was like if I take this class and make an A in this [class]. Oh my! I can't, I have to take physics, but I can't make an A in that. I didn't take AP physics in high school and all these kids are coming in with so much experience. But now … after I got that C, I made sure I'm going to get a good prof this semester and I have to fix this.

Bran tried to be more proactive in asking for help during his second semester, apart from using online forums to answer his questions, he attended office hours and supplementary instruction sessions.

In the road map, Bran represented his friends and family as birds that were accompanying him as he was parachuting down. He indicated a reluctance to share his academic struggles with his friends and family. He explained, 'I try to hide [academic difficulties] as much as possible … for me it's just whining, and no one wants to hear you whine about stuff, I don't even want to hear'. From his narrative, Bran was unhappy with both his academic performance and the social environment of engineering. His confidence to perform academically was seen to continuously drop throughout the first year. Bran reported that his confidence in graduating with an engineering degree had decreased since he first started at Kingslanding.

Benjen

One of the main reasons Benjen had chosen to take up engineering was the job prospects. He elaborated:

> graduating as an engineer will not completely ensure that you'll get a paying standard job, but it does make it really likely. I've heard so many horror stories about people going to college and then just drowning in debt and I didn't want that to be me.

Besides the monetary benefits, he enjoyed problem-solving and mathematics. Benjen had a few friends who were going into engineering and interacting with them was an added motivation.

Coming into the program at Kingslanding, Benjen noticed his high school had adequately prepared him as he 'knew what [he] was signing up for before [he] came'' to Kingslanding and the experience was 'pretty much what [he] expected'. As a result, Benjen did not face any academic challenges during the first year.

However, he still considered engineering as a challenging major because of the time commitment and the difficulty of the material. Comparing the difficulty level of high school and college, Benjen commented that he 'definitely did not have to work nearly as hard in high school'. He also noticed that he, as an engineering major, had to work ten times harder than his roommate, who enrolled for the same number of hours having taken a different major. He further explained, 'I've heard that a lot of the material just gets harder from this point on. So, if this is the easiest point, I think things get pretty hard … So, I would say it is a heart-pounding major'.

In his road map (Figure 4), he depicted his experience in terms of the relative time he had spent on his course work. As he was drawing his road map, Benjen noticed the prominence of mathematics courses during his first year:

> It's interesting to look now that I've actually thought about how much more effort I had put in Calc I and Calc II … not in an absolute sense but relative to all of my other classes. Last semester, Calc 1 was one of my only hard classes and now I think Physics 218 is just as hard. And so, I spend just as much time with those.

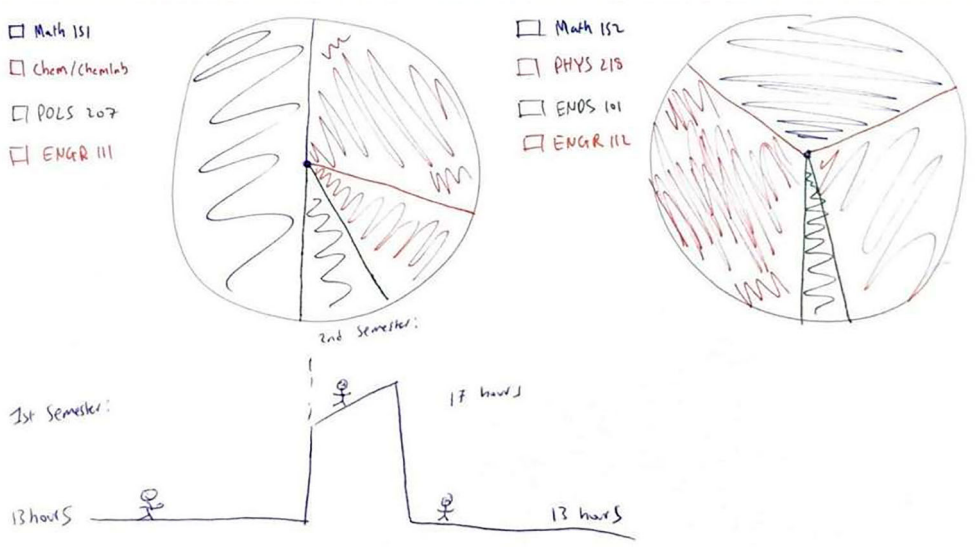

Figure 4. Road map sketch by Benjen.

While most of his journey was smooth, his only hiccup was that he took 17 credit hours during his second semester. Once he had dropped four credit hours, he was comfortable with the course load. Benjen thought 'it was kind of fun like silently laughing at all [his] friends who were spending hours [studying] … while [he] was just, you know, having a good time'. Benjen explained that he was expecting a lower grade in one of his classes, 'not because [he couldn't] learn the material, but because [he] was an idiot and skipped a lot of labs and' classes.

Rickon

Rickon took up engineering as it was a 'lucrative' field, even though he felt that it was a hard major. He, 'as a person born in the turn of the millennia', thought that 'going into engineering would be a good opportunity … because [technology is] the future'. Rickon, wrestled with the prominent social norm that 'if you don't major in engineering, if you're not in STEM, [then] you're not going to be successful in life'.

Rickon had taken advanced classes during his high school and was used to a heavy course load, however, on hindsight, he noticed that his preparation might not have been adequate. Specifically referring to his calculus Advanced Placement class, Rickon described his teacher as very competent, but 'still felt like it should have been a little more [*sic*] harder than it was', further he noticed some 'cracks in the system' from his final year or the grade 12 year at high school:

> senioritis is a thing that at the end of the year, students start slacking off … for the seniors at least, [teachers] kind of start accommodating so you can turn in an assignment 3 months late and still get full credit … And that kind of hurt, because when I came into college, I was still stuck in fun mode and I didn't necessarily take it as seriously as I should have.

The first few weeks of college seemed really easy, but Rickon was soon engulfed by academic challenges. Rickon spent most of his first semester in disbelief, he explained,

> I always think I can fix it [problem situation]. I can fix it, even though it's falling apart. I was too stubborn and my ego was too big to [say to myself], 'hey, you need to Q drop this or talk to your professor about what you can do next' and I never did.

Q drop is a way for students to drop the course later in the semester, especially to avoid an F or fail grade on their transcript. During the first semester, Rickon had a bad experience with a professor and believed most professors and teaching assistants would dismiss him, especially because he had bad grades. Receiving an F on one of his first semester courses was a wake-up call for him, when he told himself, 'you need to act like you don't know anything, and then that's how you succeed'. Thus, during his second semester, he was more proactive by getting more involved in GroupMes (a popular app for group work and collaboration among the US undergraduates), supplementary instruction sessions, study sessions, office hours and reading textbooks weeks ahead.

In his road map (Figure 5), Rickon represented his difficulties during a majority of his first and second semesters by drawing himself on a path of fire. He indicated the semester break as an oasis where most students have a chance to relax and rest, but his oasis was on fire as he had no time to relax. He noted:

> So, I'm ending off the year with a bad GPA and I have to worry about if I'm going to be able to still be in engineering afterwards, and I have to worry about what's my next move and I have to keep moving even though I want to stop.

After thinking long and hard about his future, he felt he was being led towards a variety of career paths that his university could offer. He represented the possibilities as a maze because 'it's a lot of loops and a lot of going places you don't know if you want to go to'. He included dropping out as an option,

> Not because I want to drop out, but … it feels like no matter how hard I try, the degree that I want to get in engineering is going to be blocked off and since ultimately I wasn't made for that degree, I'll end up being a dropout trying to pursue it in the end.

He described 'the biggest obstacle to the engineering major isn't itself but the mindset that comes with it'. Being in a competitive environment and seeing his peers perform better than him, he had to constantly 'overcome [an] inner sense that I can't do this'. Rickon's academic self-efficacy constantly reduced ever since enrolling in college. Further, his lack of academic and social integration negatively impacted his intent to persist. While he shifted from avoidance to approach coping strategies (Roth and Cohen 1986), he still struggled to catch-up with his peers.

Jon

Jon knew that the engineering program at Kingslanding University was great, mainly because of his dad who went through Kingslanding to be an engineer. Jon further described, 'my whole family is … engineers, I have two older sisters and they both went to engineering and one was actually at Kingslanding also.' In addition, he acknowledged that he 'hated English and History', and was 'only good at math and science' which steered him towards choosing an engineering major.

In his road map (Figure 6), during the first semester, Jon illustrated himself as being attacked with arrows by chemistry, as it was the 'the hardest part about first semester.' In addition, he is seen dodging a football as Jon was enrolled in the Corps of Cadets[2], and attending the football home games was a prominent part of the corps' requirement. As the football game took 'the whole Saturday, which wasn't too bad', it still took time away from studying. During his first semester, he felt that a hill was protecting him from being hurt by the arrows and the football. The hill represented his high school preparation in addition to 'a lot of cushion' that first-years are provided with, to correct their behaviour.

During his second semester, Jon was no longer being attacked but held the bow and arrow, indicating a perception of control. While he was shooting on target for most courses, but differential equations course was particularly challenging. '[He] drew targets, blurred in and out of reality, because that's how [he was] picturing differential equations, it's not real'. Jon was elated that

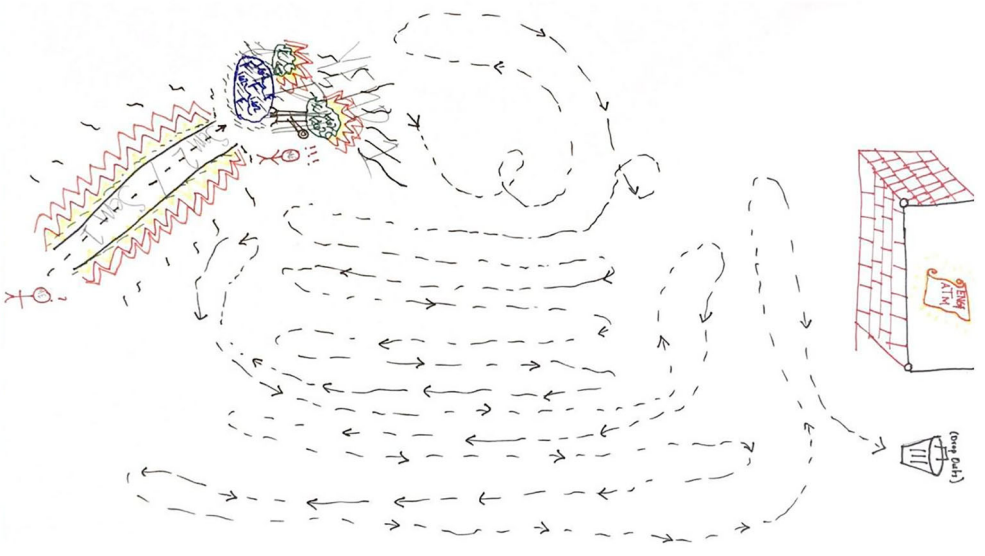

Figure 5. Road map sketch by Rickon.

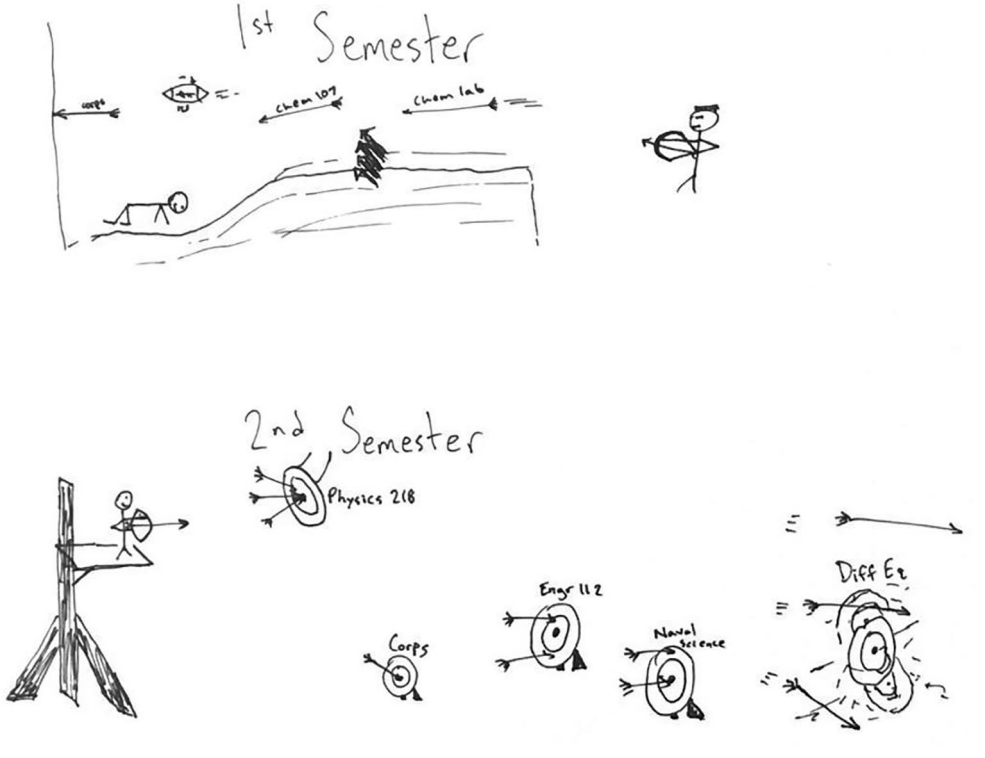

Figure 6 .#Road map sketch by Jon.

differential equations would be the last mathematics course he was required to take. Explaining the difficulty of classes at college, Jon said, 'take your toughest class in high school and that's probably going to be your easiest class in college.'

Further, he explained the role of his peers in successfully navigating the first year:

> the problem is, [studying a lot is] all people do, so … I'd say get involved and make friends with people in their major. Because that helps the most … If I didn't know anyone, I would miss a lot of assignments because … there's so many things you have to do.

Even in the face of moderate academic challenges, Jon was very confident that he would complete the degree.

Ned

Ned considered himself good at mathematics and being an engineer was one of his top career options. He explained, 'I wanted to be an engineer because it's kind of prestigious, like my sister is a dog trainer, my brother is a choir director, so I wanted to one up them.' Soon after he began the program, Ned was overwhelmed by the academic rigour. In his road map (Figure 7), he demonstrated a changing thought pattern as he progressed through the first year of college. Comparing his mind set before and after entering the engineering program, Ned explained:

> before engineering I was kind of focused on my future, work, and family and stuff that kind of mattered. And then as I started the semester off, one of the first thoughts was dropping out, you know cause engineering's pretty hard … just passing my classes was the main priority at that time. I didn't have time to think about my future or anything like that, it was pretty hard.

While being good at mathematics was a primary reason for choosing engineering, he had almost no experience in coding. Learning that engineering was heavily dependent on coding, Ned was shocked and frustrated:

> I hate coding with my life and so it's really hard. Our professors were just pretty tough on us and I'm a pretty old guy on the inside, so, I don't do very well with technology. I didn't know how to work my computer … just computer work sounds like UGH!

Describing himself as a 'math person', both physics and chemistry were tough for Ned. While his positive attitude towards mathematics helped him perform on-par with his expectations, his lack of association with other subjects made them hard for him. In order to deal with the academic difficulties, Ned explained his thought process:

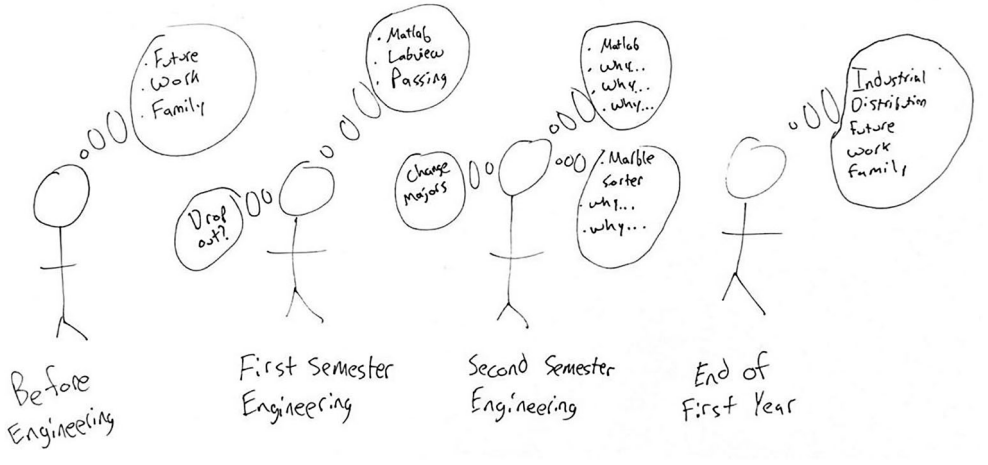

Figure 7. Road map sketch by Ned.

> how is this class going to affect my overall career? … Just passing one class doesn't really affect me. So, I just kind of lower my expectations. If I fail, I say, Oh! I can take it again as long as I get a degree and if I don't, I can still get a job.

Further, Ned attributed the challenge of the major to poor teaching practices. Describing his professors as 'bad teachers, in [his] opinion', Ned mentioned that 'they don't ever help you and they don't explain the projects or homework or anything well at all … and they don't respond [to questions]'. Throughout the second semester, Ned represented himself (Figure 7) constantly wondering, 'Why? Why are they giving me so much work? Why is this needed or necessary? Can I change my major?' At the end of the semester, he found industrial distribution, 'which had nothing to do with engineering'. Ned enjoyed his new major choice and was able to 'focus back on [his] future, work, and family.'

By the end of the first year, dissatisfied with engineering course instructors and the overall experience, Ned had essentially moved away from mainstream engineering, even though he was technically in the college of engineering. Once he chose Industrial distribution, Ned felt more integrated into the institution and his confidence that he would complete the degree improved.

Theon

The biggest factor for Theon to take up engineering was that his dad was an engineer. He was inspired to pursue engineering from a very young age. Additionally, he was fascinated by airplanes 'since [he] was a little kid' and wanted to 'do something with that, when [he] got older'. He added that engineering allows him to earn 'lots of money straight out of college', which was helpful in making his choice. In preparation to go into the engineering major, Theon attended a rigorous high school. Talking about his high school experiences, Theon explained:

> while it was definitely a very stressful 4 years, it probably over-prepared me for college … they'd make us take college level classes right from our [first] year. Although it was a pretty big jump from middle school to high school the classwork was definitely very challenging. I mean it was on the college level.

As a result of his preparation, Theon was having a much easier time in college as compared to high school:

> I kind of feel like there is a lot more work in high school that I didn't really care about but [in college] I mostly take … classes that I care about … I think because I actually care about what I'm doing it's a lot easier

In addition to facing no academic difficulties, Theon appeared to be underwhelmed by his first year. As he drew his road map (Figure 8) as his journey on an upward slope, he explicitly mentioned that the slope did not indicate difficulty, but only a progression through his courses. Describing most courses as 'easy', 'pointless', or a 'joke', Theon was able to earn A's in most of his courses. He indicated his distaste for certain group projects, which were not a major setback, by saying that the experience made him 'want to drink bleach, honestly'.

Collective characterisation of first year experiences

Based on the road maps and interviews, 7 of the 8 participants reported viewing engineering majors as challenging. Due to the implicit difficulty of the course material, students considered the courses were time and effort-intensive. Even though mathematics was one of the challenging subjects during the first year, being prepared for mathematics alone did not guarantee a smooth transition into college (e.g. Ned). Chemistry and coding were some other major problem areas. As opposed to mathematics, which was time-consuming for most students, coding was only a problem when students were unprepared. Specifically, Bran, Rickon and Ned experienced difficulties and frustration with coding. Theon noted that the creator of C++ once taught at

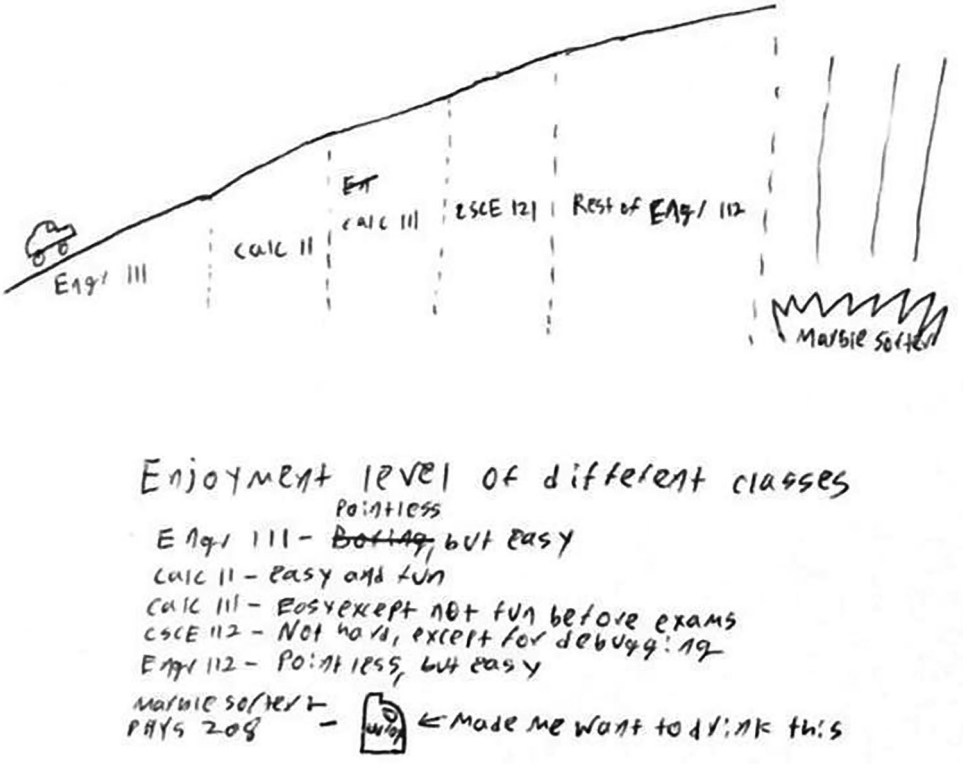

Figure 8. Road map sketch by Theon.

Kingslanding, which resulted in a difficult coding curriculum and discouragement among students.

Additionally, the faculty and advisors sometimes amplified the academic difficulty during the first year. Arya and Rickon, on the recommendation of their advisors, retook some calculus courses for which they already had college credit. They were extremely unhappy with this decision as they believed the courses were made 'harder than necessary' and it negatively impacted their grade. Theon, based on his observations, also suggested that first-year students should accept all the credit they have to advance through the courses instead of retaking them. A sense of general discontentment with advising was often reported among engineering first-year students (Myer and Marx 2014). Further, most participants commented on the importance of carefully choosing their professors and courses. Benjen noticed that 'the quality of education depends more on your teacher [at college] than it did [in high school]'. From personal experience, Bran realised that 'understand[ing] the whole professor system and picking your classes around that … it really affects your GPA'. As the course experience and grading could vary greatly by professor choice, students sometimes questioned the intent of the assessments as they are supposed to be 'testing [their] knowledge, not [their] awareness on small details' (Arya).

Persistence factors

At the end of the first year, some participants were keen on becoming engineers in spite of the challenges, while some were re-evaluating their major choice. To understand what helps engineering first-year students persevere in the program, the common themes amongst student's reactions to

challenges were examined. Participant's intent to stay in the major was driven by motivation to be an engineer, and themes of being academically and socially integrated. Whenever participants lacked an intrinsic motivation to persist, they relied heavily on perceived academic and social integration to adjust their intent to persist.

Motivation to choose engineering

With engineering majors being associated with higher-paying jobs, participants echoed a common societal norm that engineering majors are successful. Arya, Jon and Theon had family members who inspired them to pursue engineering, while Benjen was inspired by his friend group. Rob was motivated by his passion for problem-solving. Bran wanted to 'see where [engineering] takes' him, and engineering was one of 6 possible major options for Ned. Rickon was compelled to take up engineering due to the stereotype that other majors are pointless and lead nowhere. While friends, family and educators influence students' initial motivation, their intent to persist in the major is driven by internal motivation (Whitehead 2018).

During the first year, most of the courses were introductory science and mathematics which were almost unrelated to their intended major. Participants with a strong internal motivation considered this year as a stepping stone to enter their major. For example, Jon stayed in engineering 'because it's the best major' and was looking forward to being an engineer and work for the military like his father and grandfather. Arya, aiming to go into biomedical engineering, was optimistic:

> [second] year classes are not that difficult except for one computing class but I'm actually pretty excited for it because I'm really interested in computer sciences. And then … . there's a lot of research behind it too and I really enjoy research. I don't think I'll find that aspect of it difficult

In agreement with previous research, participants who identified as being engineers were likely to persist irrespective of the difficulty or effort required (Matusovich, Streveler, and Miller 2010). For these students, the challenge was 'meaningful and even enjoyable' (Cruz and Kellam 2018). However, participants who were not as strongly motivated (Ned, Rickon and Bran), used the first-year experiences to assess their fit in engineering. Rickon aiming to seek happiness rather than money explained:

> I think it doesn't matter what you major in, obviously you don't want to major in underwater basket weaving, because that's not viable in any situation, but you have to really do what makes you happy at the end of the day … you only get to live once and if you're spending the whole time doing [something you hate], you're only paying for a life that you don't even want to live.

Academic integration

Among the participants, a sense of academic integration was mainly derived from prior exposure to academic rigour and grades. There was a discrepancy between actual preparation and perceived preparation due to the variance in exposure to academic rigour. Being prepared for college was viewed differently across participants. Theon, Arya and Jon associated preparation with being exposed to advanced content through college level courses. Benjen attributed it to learning effective study strategies whereas Rob believed problem-solving skills can be adapted over different disciplines were helpful. In contrast, Bran, Ned, and Ricon associated preparedness with being 'somewhat familiar' with content or having 'quite a bit of knowledge' in Calculus. As all participants believed they were prepared, students who were unprepared were unable to initially identify their lack of preparation.

In agreement with previous research, first-year engineering students with rigorous high school preparation (Zhang et al. 2004; French, Immekus, and Oakes 2005) were able to transition smoothly into college. Specifically, some students were aware of what to expect as an engineering major. They were prepared with the required study skills and committed to put in the effort. Thus, they felt

academically integrated and their intent to persist had not changed since the beginning of the first year. Being well-prepared, these participants were able to maintain their self-efficacy belief. While they occasionally received unfavourable grades, they attributed it to rigorous grading systems rather than their inability to perform. These students were less likely to interpret their grades as a form of threat.

On the other hand, some students were overwhelmed by the jump in difficulty level from high school to college. Specifically, Bran and Rickon recognised their lack of study skills as an additional drawback compared to their high-achieving peers. Further, these participants used grades throughout the first year to assess their academic fit and revise their intent to persist. Poor grades and a feeling of under-preparedness for the rigour of engineering lowered their self-efficacy. While Bran and Rickon reacted emotionally to their poor grades, Ned lowered his expectations to avoid disappointment. By the end of the first year, some students felt less academically integrated as compared to peers, which adversely affected their intent to persist.

Social integration

All participants referred to their peers as a means of comparison and/or support. Several participants emphasised the need for first-year students to 'build themselves up with friends'' to make up for their weaknesses (Ned) and keep up with the academic load (Jon). Participants' who were confident of persisting in the major reported a consistent peer group or a sense of being socially integrated. The feeling of social integration positively influenced their self-efficacy, help-seeking and intent to persist. On the other hand, a detached comparison with engineering peers could negatively impact self-efficacy:

> everybody else around you … although they're struggling too, they seem to be doing better than you, you know, no matter how hard they struggle … when I see that I feel like since they're struggling and I'm struggling, there's kind of that connection that I should be able to get past it, but I'm not able to … so it kind of makes me like look at myself and say like what's wrong with me (Rickon).

Even though a variety of academic help was provided by the engineering department at Kingslanding University, participants demonstrated a hesitation to approach faculty. In agreement with previous research (Marra et al. 2012), talking to other students and/or friends was the most popular option for dealing with academic difficulties. Specifically, participants who were struggling indicated a lack of confidence to approach faculty or staff for help. Bran described asking a professor for help as 'iffy sometimes, because their expectation of you is a lot higher than it actually might be". Rickon did not want to 'annoy [teaching assistants and professors] especially when you're doing bad … you think they're going to dismiss you'. However, by the second semester, they realised that teaching assistants and professors were more approachable than they had assumed. Thus, participants who were integrated into a peer group often asked their friends for help, those who felt isolated tended to avoid help-seeking.

Conclusions

By presenting the stories of eight engineering students in their first year, we hope to move beyond the dominant narrative of engineering education towards building human capital and economic growth. We direct our attention to understanding the motivations, needs, and overall experience of the students pursuing engineering majors. As discussed by the transition theory (Willson 2019), we observed the participants adapting in unique ways to their new environment and navigating new connections with their institution, instructors, advisors and peers. The societal message that engineering majors are guaranteed financially viable careers appeared central to participants' major choice. While this was a motivator for several students to focus their efforts towards completion, the assumption created an internal conflict for some students. Students who had a future

time perspective of themselves as engineers were able to navigate the challenges effectively as they viewed them as a stepping stone to their ultimate goals (Kirn, Faber, and Benson 2014). Alternately, students who were persuaded to pursue engineering by external factors, constantly evaluated their fit within the program. When faced with challenges, they often evaluated if the end goal was worth the effort. Particularly, one participant in this study positioned his struggle to reconsider his major as a choice between happiness and money. Due to an increasing emphasis on STEM education, at the school-level, some students received generic suggestions that engineering was a good fit for students with high aptitude for mathematics and science. These students enter the engineering major with an inflated sense of confidence fuelled by their high school experiences (Boone and Kirn 2016). The unexpected increase in rigour at university negatively impacts students' self-efficacy beliefs and general sense of belonging within the major. Thus, there is a need for teachers and parents to acknowledge the risk of making generic suggestions and be more mindful about potential students' career choices.

At the department level, all students reported an atmosphere of competition. Often questioning if the academic advisors and professors had students' best interests at heart, several students viewed the engineering department as almost hostile. Further, students commented on a treatment of all engineering students universally by the academic advisors with no consideration for their specific interests or motivation. This lack of consideration for individual needs was a considerable obstacle for students to complete the engineering major (Litchfield and Javernick-Will 2015). During the first year, the coursework was far removed from their intended major with a majority of classes focussing on basic mathematical and scientific knowledge. As a result, students leaving the major after the first year may remain unexposed to the real scope of the engineering degree. Alternately, students suggested including applications within the introductory courses to improve their motivation and intent to persist. Further, exposure to various engineering professionals during their first year may be effective to provide realistic perspectives of the field.

Most importantly, students' perception of academic and social fit within the major influences their self-efficacy, help-seeking behaviour and intent to persist. Student motivation and experiences can be improved by ensuring better academic and social integration during their first year. To this end, researchers have suggested the inclusion of group work, cooperative learning and peer mentoring (Marra et al. 2012; Moore 2005; Pendergrass et al. 2001). More recent research highlights the crucial role of engineering professors and student relationships in improving student retention (Dika et al. 2019; Youmans 2020). Specifically, by presenting the narratives of first-year students who experience worry and isolation from their peers and faculty, we hope to highlight the extremely competitive environment experienced by the engineering students. Moving away from the macro focus of training large numbers of engineers, we highlight the need for improving the experiences of students and meeting their diverse needs within the existing programs.

Notes

1. Advanced Placement or AP courses allowed high school students to take up college level courses in the US. By taking the AP tests, graded on a scale of 1–5 with 5 being the highest, students could receive course credits at some universities.
2. The Corps of Cadets is a student military organisation at Kingslanding, one of the oldest and most prominent student organisations on the campus. Members of the Corps of Cadets have specific course and participation requirements at Kingslanding. Many of the members continue to serve in the US Military after graduation.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Interview protocol

1. Think about your journey into the engineering program and through the first year. Please draw an illustrated road map of your journey.
2. How and why did you choose the engineering program?
3. Do you consider it a challenging major? Why or why not?
4. Have you received a grade lower than you anticipated during your freshman year? Can you describe the situation and your thought process?
5. Have you received a grade lower than you anticipated during your high school? Can you describe the situation and your thought process?
6. When you have academic difficulties, how do you deal with them?
7. Can you describe your social support system?
8. What advice would you give to an engineering freshman?