



## **Exploring the Impact of Engineering Student and Professor Expectations on the Development of Student Engineering Identity and Navigation**

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## **Introduction**

The “engineering pipeline” is a frequently discussed metaphor that describes students’ progress through the educational system toward a certified degree in engineering<sup>24</sup>. To explain how students navigate through this so called pipeline, sociocultural learning theories posit that learning in a specific discipline or major entails becoming a certain kind of person in the world. This implies that learning is more a process of identity formation than a formal development of knowledge, meaning for students to successfully navigate through the engineering pipeline, they must successfully acquire the identity of an engineer<sup>9,11</sup>.

But what does it really mean to be an “engineer”? The answer to this question likely depends a great deal on who is asked; the CEO or hiring manager of an engineering firm, a college engineering professor, as well as an undergraduate engineering student are likely to all provide different responses to this seemingly straight forward question. Despite these likely discrepancies, it would seem that the identity of an “engineer” is held as a universal constant in engineering education research conducted through the lens of identity theory<sup>13,14,19,26</sup>.

It seems plausible that a mismatch in engineering identity conceptions between undergraduate engineering students and engineering firms could be partially responsible for students’ failure to acquire essential engineering skills while they are in college, as research has shown that engineering school graduates often times lack numerous skills that professional engineering firms deem to be important to succeed in the workplace, such as the ability to communicate and work well with others<sup>10</sup>.

Mismatches in engineering identity conceptions between undergraduate engineering students and their college engineering professors may also be contributing to the high levels of engineering student attrition. Research has shown that nearly half the students who begin college as engineering majors do not end up graduating as engineers, with nearly half of this attrition occurring during the freshman year<sup>3</sup>. More recent data collected by the American Society for Engineering Education (ASEE) in 2015 shows that average college graduation rates for engineering students in public universities is around 50%, while the graduation rates at private universities are around 69%<sup>1</sup>.

This paper aims to broadly explore and discuss how student and professor expectations may influence students’ conceptions of engineering identity, their acquisition of knowledge and skills, as well as their plans for navigation through the “engineering pipeline” by analyzing the interview responses of two freshman engineering students and one engineering faculty member.

## Motivations

As stated earlier, it is important to acknowledge that engineering identity is not necessarily as concrete or fixed as research might suggest<sup>13,14,19</sup>. It is likely that each individual student possesses a different understanding of the engineering profession, as well as how they fit or do not fit into that field. When the word engineer is invoked, it may have different meanings and implications to different students. I posit that the differences in students' engineering identity conceptions are primarily shaped by theirs' and others' expectations of themselves, the structure of college courses as well as their understanding of the engineering discipline.

While much research has been done on student identity development and retention, it would seem that little work has been done to examine professors' identities and views within the field of engineering<sup>4,12</sup>. Given that the expectations of professors can effect student confidence and motivation to become engineers<sup>5</sup>, it is likely a worthwhile pursuit to develop a more sophisticated understanding of professors' engineering conceptions because their views of what it means to be an engineer (and to be a successful engineering student for that matter) are likely quite influential on classroom practices and resulting student engineering identity formation.

### *What are expectations and why are they important?*

Expectations are the beliefs of individuals that something will happen or is likely to happen, what something will be like and what people and things are involved, as well as their feelings or beliefs about how successful or good someone or something will be. Based on this definition, expectations should be considered an important variable in shaping student success and retention because they are the very foundational lens that students use to measure theirs and others' experiences and performance throughout their lives; as the common saying goes, "expectations are the root of all heartache". If incoming engineering students' experiences in college are vastly different (and perhaps disappointing) from their expectations, it is very possible that students' performance and resulting motivation to study engineering may suffer or that they may choose to remove themselves altogether from the engineering discipline as the high engineering student attrition rates suggest.

As such, it is seemingly important to develop a better understanding of what expectations students may have regarding their experiences in an engineering college with relation to their classes, learning goals, acquisition of knowledge and skills, extracurricular activities, internships, social experiences, the overall discipline of engineering as well as where they expect to be after graduation and beyond after attaining their engineering degree. Similarly, it is important to also assess students' expectations regarding their interactions with and beliefs about peers and professors, and vice versa, to better qualify the measures students use for assessing their performance in school and forming their personal identity. While expectations can be both wide and narrow in scope, this paper will explore the general expectations that students and professors have on a broader college level scale rather than the more narrow scale of a specific classroom setting or a particular engineering course.

## **Research framework / The map analogy**

I was initially inspired to complete this study due to my own personal experience and intuition regarding the subject. Having navigated through a four year undergraduate engineering program in civil engineering myself, I can recall how different my initial experience of engineering college was compared to what I had expected it to be. Not only were my classes quite different than I had imagined, but there were many other things about college life for which I did not adequately account or prepare for at all. As a result, I struggled mightily during the first semester of my engineering degree; for whatever reason I continued forward in engineering despite these setbacks and pushed forward due most likely to my passion for engineering, my belief in myself and my ability, as well as some other collection of external and internal pressures. I am conducting this research because I am curious to find out if other engineering students share similar experiences to mine, and to better understand how student and professor expectations might influence these experiences. As is likely true in all research, my initial understanding of the topic evolved as I conducted my interviews. However, the underlying analogy I had originally conceptualized still proved to be helpful in characterizing my research goals and developing my interview protocol. I explain this analogy or metaphor by comparing a student's journey through their education to someone preparing for a standard trip in the section below.

Before someone starts on a journey they typically consult a map to make sure they know where they currently are and where they are planning to go, so that they can chart a course of travel and best prepare for what is to come. Travelling to their specified final destination is made easier by having this sort of awareness. The same could be said of college engineering students, as they seemingly begin their education with the goal of becoming a practicing engineer. The instructors whose intentions are to teach and guide the students to this destination, have already traveled to the end point of graduation that students wish to travel to. As such, the instructors intimately know the ins and outs of the path and what parts of the journey are the most critical. In contrast, because students have little formal experience with engineering they may have a totally different set of expectations and beliefs about their upcoming journey than their professors do, such as where it should ultimately lead and what parts of the journey are most important.

A disconnect between professors' and students' expectations in a classroom setting or at an institutional level may result in a misguided journey for students as they focus on the things that they think are important, rather than focusing on the things that professors, practicing engineers or the engineering college believes to be important. This mismatch could lead to students getting lost and disoriented with their travels, meaning they don't obtain the necessary skills or make it through to graduation at all. In this paper I hope to better characterize how students' conceptions of engineering identity along with their expectations may influence their planned path through college.

## **Research methods and protocol**

To explore student and professor expectations and conceptions of engineering identity, I conducted three separate IRB approved interviews that were each approximately one hour in length. The audio of each interview was recorded and later transcribed. The interview participants were comprised of two first semester, freshman level engineering students whom I will call Jimmy and Kimmy as well as one engineering professor, whom I will refer to as Professor X. During the interviews, I utilized a semi-structured protocol which allowed for slight modifications to standard questions and for related follow-up questions to be asked.

The participating students were recruited via an email announcement as well as by third party invitation and recommendation; neither student had any previous contact with the interviewer (i.e. myself). Professor X was invited to participate in the research due to his younger age, which I believed would help him recall his college experiences more readily, as well as his personal rapport with myself.

Given the exploratory nature of this study and the smaller non encompassing sample size, I have chosen to qualitatively analyze the interviews rather than to conduct any sophisticated quantitative analysis or qualitative coding. In order to provide further insight into what role expectations might have in engineering education, and to explore how expectations might affect student navigation through their discipline I do my best to provide contextual descriptions and interpretations of the interview data as is customary in qualitative research<sup>15,17</sup>.

I acknowledge that my development of the interview protocol and subsequent analysis of the interviews are likely influenced by my own experiences in college as a student and a professor. To ensure that my analysis of the interviews was as objective as possible, I collaborated with several advisors and colleagues to interpret and analyze the interview responses; these advisors and colleagues are mentioned in the acknowledgements section of this paper.

## **Description of interview participants**

In order to frame the participants' responses to the selected interview questions, I will provide a brief overview / characterization of each interview participant.

Jimmy is a first year computer engineering student, as well as a first generation American and a first generation college student. Jimmy is from a local suburb of the college and has an older brother who is currently in college, as well as a younger brother and a younger sister in high school and middle school respectively. Jimmy seems to be very passionate about the field of engineering and chooses to focus very intently on his engineering studies at the expense of involving himself in other extracurricular activities.

Kimmy was initially a first year materials science engineering major, but decided to switch into civil engineering due to her interest in project management, or more importantly due to her disinterest in the micro-scale and research heavy world of materials science. Kimmy is part of a living and learning program designed to provide support for incoming freshmen girls in engineering. Kimmy seems to work hard, but suggests that her grades are not as high as she would hope them to be. In addition to focusing on her classes, Kimmy also seems to be

interested in participating in non-engineering related social extracurricular activities.

Professor X is a relatively young professor that graduated from the same University as both the students in the interview. Professor X majored in mechanical engineering as an undergraduate and now works full time for an engineering firm that deals primarily with computer engineering. In addition to working full time, Professor X is also participating in a master's level graduate engineering program.

Although all three interview participants provided excellent responses and insight into the interview questions, I generally found the contrasting answers provided by the two students to be more interesting and rich with information than those provided by the professor. As such, while I do utilize interview excerpts from all three participants, my analysis of the interviews tends to focus more heavily on the students' responses.

### **Interview data and analysis**

#### ***Differing views of engineering***

Based on the interview data, it would seem that my earlier assertion that students and professors tend to have varying views of engineering practice seems to be relatively true. When I asked the participants to describe in their own words what an engineer was, I received the following answers.

*Jimmy:* An engineer is anyone that takes one of the hard sciences, chemistry, physics, and biology, I think that's all of them and then they apply it in a way that make life even more efficient for us or solves a problem that faces humanity.

*Professor X:* That's a good question to begin with, ok, an engineer is, someone who can use the knowledge that they have gained either through school, through extracurricular activities, uhm, through life experiences but somebody that can apply all of that knowledge.....and either develop a solution or come up with a new product....

While both Jimmy and Professor X's definitions of an engineer are structurally similar, that engineers use knowledge to solve problems, each provides slightly different sources of where that knowledge comes from. While Jimmy states that engineers' knowledge comes simply from the hard sciences of chemistry, physics and biology, Professor X attributes engineers' knowledge to multiple sources including school, extracurricular activities and life experiences. This small distinction would seem to suggest that Jimmy expects that he and other engineers acquire a great deal, if not most of, their serviceable engineering knowledge from classes alone; this expectation seems reasonable given the fact that he is a first semester engineering student that has not yet really practiced engineering or significantly participated in any extracurricular activities. Professor X, having an engineering position in the real world, has a greater appreciation for the many different knowledge sources engineers use in addition to that gained in their classes. It is also interesting to note that Professor X seems more prepared and eager to answer the question using his own personal experience than Jimmy seems to be. As a result of his experience Professor X seems to answer the question by incorporating some of himself and his skills into his definition of an engineer, whereas Jimmy has to draw upon others like his uncle and

institutional criteria like coursework to develop his definition. As you will see later in the interview, Jimmy's view of engineers may be causing him to place a heavy emphasis on his coursework at the cost of not involving himself in extracurricular activities, or at least this is so at this point in his education.

### *Engineering skills / identity projections*

In addition to asking the interview participants to describe what an engineer is, I also asked them what sorts of skills were important for an engineer to have to be successful. Jimmy responded to this question by saying that creativity, goal orientation and responsibility were the three most important skills for engineers to have, while Kimmy suggested that communication, the ability to complete engineering work, organization and critical thinking skills are most important. While all of these skills are likely to be important to engineers, it was interesting to note that during Kimmy's response, she projected a lot of her stated personal strengths to being important to engineers. For example, look at Kimmy's response to this question below:

*Kimmy:* Definitely one of the top is communication. Other than just the ability to actually do the work, I think communication is key. As like a people person, as I guess I call myself, the people in my engineering group that just don't communicate or just don't show up, it's just, we look down upon you....Also organization. Since I am organized personally, that's a huge one to me at least, it sticks out. Critical thinking, definitely up there.

I think that Kimmy's response is particularly interesting and further reinforces the idea that each individual has a different view of what an engineer is and what skills an engineer needs to be successful. Most importantly, it showcases that individuals tend to project themselves and their skills onto their intended identity as an engineer. While communication and organization are seemingly important skills for engineers to have, Kimmy reinforces that she has these skills out loud while she is interviewing, almost as a subconscious way to ensure herself that she can fit her perceived identity of what she believes an engineer is.

While both students discussed particular run of the mill sorts of skills, Professor X expressed that the most important skill for an engineer to have was a willingness to fail, and an ability to learn and grow from that failure; this would tend to suggest that Professor X views engineering as an experiential and iterative process. As a former engineering student and current engineering professor I can see how Professor X's view of engineering as a challenging process might result in the difficult examinations and projects that engineering students are often times given, albeit much to their chagrin. While I did not ask this specifically to either of the students, I would hypothesize that if I were to ask them how they viewed "failure", their responses would likely not paint it in as positive a light as Professor X does; the likely expectation of failure being perceived as a bad thing may result in students being overly cautious or closed minded in their engineering classes, particularly those that are project based, which could result in them not learning subjects and concepts as deeply as they could be.

### *The impact of expectations on student involvement*

In addition to having differing opinions on what engineers are and what skills are important to them, the student respondents also had noticeable differences in opinion when it came to the purpose of extracurricular activities.

Jimmy tends to view extracurricular activities as an opportunity to gain further hands on experience and knowledge about subjects that relate more to the real world. For example, Jimmy suggested he was eventually interested in joining the Engineering Car Racing team because he was simply interested in learning more about how cars work and function. Beyond learning, Jimmy did not see too much value in extracurricular activities. Because he expected that engineering companies would be more intently focused on his grades when considering him for internships or future careers, Jimmy designated that he intends to prioritize his studies rather than involving himself in extracurricular activities. This decision seems to align well with Jimmy's earlier assertion that responsibility and goal orientation were important engineering skills; as an engineering student, Jimmy tries to stay focused and dedicated to his studies rather than involving himself in other learning opportunities.

In contrast, Kimmy expected her involvement in extracurricular could serve as a way to help market herself to engineering companies that were considering her for internship opportunities. When I asked Kimmy why she thought her involvement in these activities would later help her get internships, she explained that the socially oriented clubs that she was interested in such as the Society of Women Engineers, the American Society of Civil Engineers, as well as a service outreach club would enhance her networking and communication skills and thereby increase her marketability to engineering firms. Unlike Jimmy, Kimmy suggests that her participation in extracurricular activities is integral in her development and future marketability as an engineer; she does not mention having interest in these activities to help her advance her engineering learning, but sees them instead as a way to network with fellow engineering students. However like Jimmy, Kimmy's response to this question seems to also fit with her earlier assertion that communication is an important engineering skill; it could be for this reason that Kimmy seeks to involve herself in socially oriented extracurricular activities.

Through Jimmy's and Kimmy's responses, we can begin to see how a student's expectations might play an important role in shaping their navigation through their respective engineering discipline and towards their ultimate engineering identity development. In this particular case, both students' expectations regarding particular skills and their acquisition of those skills seem to play a role in what types of activities these students choose to participate in, or to not participate in. Student's participation or non-participation in different activities would lead to the development or non-development of various experiences and skills that could further promote engineering identity formation.

Taking a view that was somewhat between the students, Professor X stipulated that in his hiring experience, if two students were to have similar grades, then extracurricular involvement would be used as an important differentiating factor in the hiring process. Professor X explained that he thought these experiences (specifically Engineers Without Borders) were helpful to students because they provided them more exposure to engineering knowledge as well as improved social interaction skills. I find it interesting that Professor X's answer is more or less a compromise



between the answers of Jimmy and Kimmy, that achieving high grades and participating in extracurricular activities are both important to becoming a successful engineer; this view likely stems from Professor X's first hand involvement in extracurricular activities as an engineering student as well as his current position within an engineering company

### ***Becoming an engineer***

In addition to studying student and professors' expectations of what an engineer is and what skills are important for them to be successful, it is also relevant to develop an understanding of student perceptions with regard to when they believe they will become an "engineer". Throughout the interview, students did make clear distinctions between engineers and engineering students, acknowledging that while engineering students identified with the engineering discipline, they recognized that they were not yet by definition true engineers. When I asked the two students when they thought they would become true engineers, based on the definition that they each developed, I noticed distinct differences in their responses and timelines for this process which are shown below.

*Jimmy:* To be a perfectionist at it I feel like it's when I retire and I'll feel close to it, but getting a general sense of it, I guess like once I am like on, like, halfway through my career...

*Kimmy:* Uhm, after having gone through more than just an introductory course to my major. Uhm, and seeing how what I am going to learn or have learned will apply, uhm, and you start thinking about like the problems in the field or what challenges are you going to face...

On one hand, Jimmy seems to acknowledge that becoming an engineer is a process that is seemingly never ending, as he stipulates that he will not feel like a truly confident engineer until he retires. This response is very interesting, because it suggests that students may not necessarily think or believe that school will singlehandedly make students feel like, or identify themselves as true engineers. It is interesting to note that Jimmy acknowledges that he will not be able to learn and attain all of the necessary skills to become an engineer from just involving himself in his engineering coursework, but this is exactly what he does as a student. It would seem that Jimmy believes focusing on coursework is an important prerequisite to prepare and market himself for future jobs, which once secured will provide him the ability to gain the real world experience he equates with being able to identify as an engineer. It would seem somewhat contradictory that Jimmy values real world experience as an important developmental tool, but tends not to involve himself in other campus activities that would provide him those sorts of experiences.

On the other hand, Kimmy responds in a quite different way than Jimmy; she believes that after taking a few more courses in her chosen engineering discipline, that she will be able to more appropriately identify herself as an engineer. This would seem to adhere to the findings of engineering identity research that explain that engineering students begin to identify themselves more strongly with the field of engineering as they navigate further along in their degree<sup>15,20</sup>. Perhaps based upon this belief, Kimmy feels less pressure to focus only on her coursework like Jimmy does, which has possibly motivated her to seek out extracurricular

activities that are not necessarily intended to enhance her engineering learning, but are intended to enhance her communication skills and marketability to engineering firms.

Ultimately, these findings are important because they seem to suggest that students' expectations of *when* they become engineers, can influence their navigation through college by affecting their level of focus on courses as well as their involvement or non-involvement in extracurricular activities. It is also important to point out that the attainment of engineering identity is vastly different between these two particular students. This would likely suggest that students' engineering identities do not follow some pre-defined rigid trajectory; rather students' engineering identity is artificially and uniquely shaped by their own beliefs and expectations regarding the field of engineering and its practice.

### *Sources of student expectations*

Throughout the interviews both students commonly sighted various expectations regarding their passion about engineering, the meaning and weight of different grade point averages, as well as how others, like peers and professors, might view their actions within the program. When I asked the students where they had gotten their information, or why they believed what they did, they commonly cited different outside agents responsible for helping them form these expectations. The most commonly cited source that the students identified for having their beliefs was the proverbial "they".

While sometimes the students were able to identify a particular source of "they" when I questioned them further, they were other times unable to identify a specific entity or person. This would seem to align well with previous research suggesting that students' identities in engineering are double sided, meaning they are constructed by the students themselves as well as their positioning by others<sup>13</sup>. While I agree with this position, the responses from the interviews indicate to me that identity formation may more appropriately be referred to as being triple sided. By this I mean that identities are not only influenced by an individual's own understanding of their position as well as how others and institutional practices position them, but their identities can also be greatly influenced by a third, sort of imaginary or nonexistent, party known as "they". This would seem to suggest that unidentifiable outside agencies or general hearsay and rumor can also play a significant role in the expectations, identity development and navigation of engineering students through college. Perhaps this so called agent "they" does not come from an outside source at all, but rather is a projection of one's own internal beliefs and expectations regarding the field of engineering. Within the student interviews the outside source of "they" was often cited to justify each student's particular position in and behaviors and navigation through the field of engineering.

Other commonly cited sources that students identified as influencing their beliefs about engineering, their relative positioning to others as well as their plans for navigation included online forums, like college confidential and Reddit, as well as the class "average". Jimmy admitted that he has and continues to do quite a bit of his own research on college forums to discover information regarding how he should navigate through college and how he should be measuring his performance. Although he admitted that this is likely not the most trustworthy of sources, he seems to hold the advice and tips he gets from the forums in pretty high regard. For example, Jimmy cited that the website College Confidential helped form his expectations of what his minimum GPA should be, as well as what the other GPA levels could actually mean about

one's knowledge of engineering. Again it might be possible that Jimmy's belief in these outside sources is coming from an internal desire to adhere to a specific set of personally achievable criteria that supports his development of an engineering identity. As evidence of this claim, Jimmy sets a higher minimum GPA threshold than Kimmy does to be considered successful and marketable to engineering companies. While I have no actual data on the student's grades, Jimmy and Kimmy's answers seem to suggest that they have set their GPA thresholds using their current grades as a benchmark.

Kimmy on the other hand commonly weighed her performance in her classes the more old fashioned way, by comparing her scores to the class average, rather than looking at online forums. Throughout the interview Kimmy compared her performance to others multiple times, typically concluding that because her score was below average that she was not doing as well in her classes as she thinks she should be. Because of this it seemed that Kimmy would frequently ask others what they got on their tests so that she could compare how she did. It was interesting to note that although she commonly asked others for their grades, she did not always feel comfortable divulging her own grades on exams unless she scored highly. Kimmy also expressed a general sense of being disappointed with her performance in college courses thus far. This disappointment seemed to stem not only from her comparing her present scores on exams to her classmates' scores, but also her comparing her present scores and performance to the performance of her former high school self. Given the generally competitive nature of engineering college admissions, most engineering students are likely among the highest performers in their high school with excellent test scores and grades alike. Having likely received high grades for their entire academic career, these students likely set high expectations again for their grades in college courses. However, transitioning to college classes where test scores are typically computed on a curve and can often be very low can be quite jarring to the students who are used to scoring so well. This could in turn hurt their self-confidence and identification within their chosen discipline, as it seems to have done for Kimmy at this point.

Ultimately, I believe these findings indicate how influential other resources such as "they", online forums, and comparisons to previous self-performance can be in setting student expectations, which are key in developing a students' identity and strategies for navigation through their college career.

### **Internal and external pressures / forces**

Another theme that emerged from the interviews was the various internal and external forces that served to form student expectations and influence their navigational choices through college. I identify these influential forces below, and try to characterize how they may impact the student's identity development.

#### ***External pressures***

For Jimmy, one of the major forcing agencies in his life and his college education was the external pressure of his parents. Jimmy summarizes this pressure below:

*Jimmy:* I guess it also has a lot to do with, well I am, one first generation American and

two first generation go to college so I also have this external pressure, like I can't let my parents down if I like slip and go to the gym and play video games and stuff I am not going to concentrate on my studies...Like it sucks, like being uhm like playing video games and stuff like that to me is really fun and like really exciting but because of my workload I can't do it...So, there is just a lot of things that I hate sacrificing, I guess we will see in the future if it pays off, but yeah it just really, no one prepares you for this in high school or in middle school. No one prepares you for the choices you have to make....

Due to this external pressure, which may or may not truly be attributable to only his parents, Jimmy again justifies spending a significant amount of time focusing on his studies. This pressure seems to be so substantial, that Jimmy says that going to the gym or playing video games, two activities that he enjoys very much, would qualify as being potential barriers to his success in his engineering classes. I find it very interesting that Jimmy is struggling to balance his old high school identity, which allowed him to play video games and frequently go for runs, with his new intended identity of becoming an engineer. Jimmy stipulates that the difference stems from the fact that in high school things did not seem so serious, but now that he is in college preparing for a future career, things just feel different. In relation to this identity struggle or reformation, Jimmy also brings up an interesting point shown below:

*Jimmy:* ...it's not even about being social, it's about having fun. It's really going to desensitize me to loving engineering if I feel like it's a burden.

I find this particularly interesting because it helps to highlight Jimmy's internal struggle with forming an engineering identity. Finding a balance between having fun and more or less being himself seems at odds with his goals of working very hard in his classes to prepare himself for his future career and to make his parents proud, or to not let them down. As of right now, it would seem that the external forces on Jimmy appear to be the winning force that guides his navigation through his engineering degree.

Like Jimmy, Kimmy also has sources of external pressure that seem to influence her behaviors and resulting identity formation and navigation through her degree. As is shown in the excerpt from her interview below, these sources of external pressure continue to originate from her peers.

*Kimmy:* You want to have that balance and you want to try to not be a bookworm the entire day, entire weekend. But, like sometimes I have weekends I just feel so guilty and pressured if I don't do homework on Fridays or Saturdays...the people on my floor have the same drive and it's awesome of them, but like when I see them doing homework I'm like oh my gosh I have to go back and start doing this homework. So sometimes I put a lot of pressure on myself and then I don't even get the grades that I want, so it's like what can I do more, to get the grades that I want?

While research has identified that an individual's identity formation can be influenced by others positioning that individual, this statement by Kimmy would also seem to highlight how important one's positioning of themselves relative to others is. Essentially, rather than others

actively positioning Kimmy, it would seem more accurate to say that Kimmy actively positions herself against others.

### *Internal pressures*

While I characterized the above pressures as stemming from the external sources of parents and peers, it might also be quite relevant to consider that those external pressures can also influence or transition into a sense of internal pressure. Regardless of where the source of pressure is precisely attributed, another pressure that students may place on themselves can be perceived as perhaps being a bit more internal, as is highlighted in an excerpt from Kimmy's interview below.

*Kimmy:* Like I'm a freshman in engineering now, but we think that we are like the best, even just like first semester freshman, we have like this intuition, or that's not the word, but we have this idea that we are the best uhm on campus essentially. I mean like STEM majors are like where to go personally, like art history is not where you want to go I don't think, like STEM is definitely where it is.....Where it's like oh, business is so much lower than engineering, but I guess we really don't know it's just what we here and it gets passed down.

This excerpt would seem to reinforce other engineering identity research, which suggests that engineering students begin to identify more and more as a separate group from the rest of their college peers; given that the students at this university were already admitted as full time engineering students, these beliefs or perceived differences between them and other college students seem to be already prevalent rather than needing to form over time<sup>13</sup>. To me, what stands out as particularly striking is the superiority that Kimmy attributes to engineering majors. Kimmy's response seems to highlight how individuals that categorize themselves as part of a group, in this case engineers, leads them to display in-group favoritism when comparing themselves to other groups<sup>26</sup>. I believe that these sorts of beliefs are likely very influential in the formation for student identity development and navigation. As was earlier suggested Kimmy formulated a lot of her expectations, identity and schooling strategies based upon the performance of her fellow engineering peers. This particular example showcases how a student's views of other non-engineering disciplines could likely influence their views of themselves and their decisions to remain as an engineering major despite academic struggles. Perhaps students feel a pressure to remain in engineering, because if they were to switch out then they would be losing the high status that came with it, and accepting that they are perhaps of a lower status by choosing to do another major. This seems to be the case for one of Jimmy's friends who does not like engineering, but is afraid to switch and tell his parents.

*Jimmy:* A lot of kids surprisingly are in engineering simply because their parents are like "engineering is the way to go, it's the future, there's engineering jobs everywhere" and they really hate it.

*Jimmy:* One of my friends he like really doesn't like engineering to the point where he is in the engineering course or something, he is like failing that class...he just really hates it, it is just something he is not passionate in. If you are not passionate about something, how are you going to like try your hardest? As far as I have talked with my friend, he is like really hesitant to tell his parents that like, he doesn't want to be an engineer.....

This particular conversation ended with a quote that I found very intriguing from Jimmy. The quote seems to highlight his belief that one can only be a successful engineer if they are truly passionate about it and that regardless of different pressures that may be forcing one to switch out of engineering, one must have an internal pressure and passion keeping them in it. Engineering students without strong intrinsic motivation to study engineering, such as Jimmy's friend is being pushed into the field, are more likely to switch out of the engineering major<sup>26</sup>.

*Jimmy:* I love engineers but I would hate for an engineer to be an engineer who hates engineering, because is that really an engineer? I don't think so.

### **General uncertainty and hesitation toward engineering**

The last topic that I will discuss is the general uncertainty and hesitation that students seem to have regarding their expectations for college. While four year universities have existed for quite some time, and their goals are seemingly well established, it seems to strike me and also the students off guard at how underprepared many people are to adjust to a life in college immediately after completing high school. As a high school student, choosing a college major is a truly significant decision with a great deal of time, money and of course mental resources at stake as it is perceived that one's choice of major will greatly influence one's career trajectory after graduation. It is interesting that students are tasked with making these life altering decisions with a rather incomplete (probably an understatement) understanding of what engineering, and a degree in engineering really entail. The following comments shown below, all seem to showcase this uncertainty or hesitation in picking a college major with limited information or experience.

**Interviewer:** Are you at all concerned that when you start doing civil classes you will think oh no you made a mistake?

*Kimmy:* Sighs, yes it is always a concern. Uhm, I am hoping that I will stick with it more so, uhm, cause I like organizational things and transportation is like how you organize traffic and flows and I am hoping that my general interest in organization patterns will lead to that. I mean it is always a possibility that I could switch again, but I really hope I don't have to.

And similarly from Jimmy.

**Interviewer:** Do you think it is weird that you are studying to become a computer engineer even though you don't fully understand what it is, and that maybe no one has ever really explained it to you or shown you what these things are?

*Jimmy:* Yeah. I like, I am always in like this constant struggle...it kind of worries me but I feel like I made the right choice but I guess I will see as I progress on this.

**Interviewer:** That is a pretty big life choice to make without all the things...

*Jimmy:* It is! And that's why I feel weird about college all the time because we are forced to make these like life choices that are, I mean not only do they affect us for the rest of our life but they cost a lot of money upfront.

Professor X also reflects back on his choice to choose a particular engineering discipline.

**Interviewer:** was there a particular type of engineering this inspired you to study?

*Professor X:* The math and physics that was kind of probably, actually I probably did not even know that engineering was a field per say, I just knew that math and physics were what I liked to do. So, I don't think I knew a field at the time for sure. I came into college, I came into undergrad as an undecided engineer.

**Interviewer:** Which engineering did you ultimately end up studying?

*Professor X:* Mechanical engineering.

**Interviewer:** And why did you choose that particular realm of engineering?

*Professor X:* I chose mechanical because I saw it as the most general engineering that was offered...as in, I did not know if I wanted to do computer, I was interested in biomedical at some point. I certainly enjoyed the civil or static classes that I did but I did not know if I wanted to do that. I kind of didn't know what I wanted to do, so I took more or less as mechanical as much as I could, you get exposed to most concepts of engineering at the undergraduate level and then towards my senior year I took more specific track like courses that put me more like into control systems and what I am doing now which is a lot of computer engineering actually.

This uncertainty and hesitation in choosing an engineering discipline is likely an important point to consider. How can engineering educators expect students to successfully develop an engineering identity and navigate through college toward that identity when they really don't understand what that identity even is? Perhaps this initial hesitation and uncertainty ends up causing a great number of college engineering students to question whether or not they want to pursue a career in engineering after graduation if they persist in the major that long; Lichtenstein et al reported that only 42% of college engineering seniors in their study definitely intended to pursue a career in engineering upon graduation<sup>28</sup>. Research seems to suggest that students who have a limited knowledge of the profession and limited experience with engineering like activities before college are more likely to switch out of the major<sup>26</sup>. This evidence seems to reinforce the idea that every individual student has a different view / understanding of

engineering identity; due to their various backgrounds, pressures, motivations, and expectations of engineering, individuals likely shape their own definitions of what an engineer is as well as how they fit that image. This development of a personal engineering identity dictates why each student takes different navigational pathways through engineering college trying to become whatever version of engineer that they themselves have imagined and why they may ultimately forgo a professional engineering career.

## **Discussion**

Overall, this paper aimed to contribute to the understanding of how student and professor expectations may influence how students develop their engineering identity and how this identity shapes the intended navigational pathways that they decide to take while seeking their undergraduate engineering degrees. While the sample size of this study does not allow for any major conclusions to be drawn, it does bring forth and highlight several interesting ideas that seem to warrant further exploration.

Firstly, the interview results seem to suggest that engineering identity is not as fixed a point in education as one might think. Rather, engineering identity is likely different for each and every individual student based upon their particular expectations regarding the field of engineering and its study as well as from their own personal beliefs and engineering self-efficacy. It would seem that students tend to project their own skillsets and agendas onto their engineering identity to formulate their own definition of engineering that best suits their particular needs and goals. These various definitions of engineering identity seem to have a significant impact on how students plan to navigate through their undergraduate engineering degree by influencing their attitudes toward and participation in academic studies and extracurricular activities.

Secondly, student expectations seem to be developed over time and via many different channels that are both internal and external to the student. Similar to how students seem to develop their own personally suited definition of engineering identity, so too do students develop their own personally suitable set of expectations toward performance and acquisition of skills. Each student's perception of engineering identity and engineering self-efficacy seems to influence how students measure their performance and standing within the discipline which in turn influences their overall development of their particular engineering identity. This cyclical loop of expectations and identity development also seems to affect the navigational pathways that students plan to take as undergraduate engineering students, for better or worse.

## **Suggestions for future work**

While the information obtained from these interviews has shed light onto the field of engineering identity formation in relation to student expectations, there is much more work that could be done to better understand this potentially rich topic.

Firstly, it would be advantageous to follow the experiences of Jimmy, Kimmy and other engineering students as they progress through college to see how their views of engineering identity, their established expectations and goals, as well as their involvement with extracurricular activities may evolve over time in response to their initial expectations being met



or not met. It would be interesting to look for trends that may develop as students progress through their engineering studies and observe how these trends may influence students success and persistence within their particular engineering discipline.

Additionally, it would be advantageous to interview a greater number and variety of students and especially engineering professors to provide a more encompassing understanding of expectations and their role in engineering identity formation by allowing for more generalizations and contrasts to be drawn between interview participants.

For example, it would be interesting to compare and contrast student and professor expectations across particular engineering disciplines, like civil or mechanical. It might also be interesting to further investigate the expectations and practices of engineering faculty involved in teaching project based versus lecture based courses to determine if curricular practices align with professor and institutional expectations regarding the important engineering skills that students should acquire before graduation.

Ultimately, I hope that the insights gained through this and future studies may provide first-year engineering students with a more comprehensive and clearly explained set of expectations than most four year plans currently available at universities; it is my hope that with a better understanding of what lies ahead, students can more appropriately set their expectations and successfully navigate through their engineering degree. By doing so, it may be possible to increase student retention rates and produce more skilled and capable engineering graduates.

## **Acknowledgements**

I gratefully recognize the assistance of Dr. Janet Walkoe, Dr. Andy Elby, Dr. Ayush Gupta, Dr. Diane Jass Ketelhut as well as Stephen Secules for their help inspiring and promoting my work on this paper.

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