

Engineering Students' Negotiation of Identity Congruence

Dr. Abigail Clark, Ohio Northern University

Abigail Clark is an assistant professor of mechanical engineering at Ohio Northern University. She holds a PhD in Engineering Education from The Ohio State University. She also holds degrees in Mechanical Engineering from Ohio State and Ohio Northern University. Prior to her time at OSU, she worked at Battelle Memorial Institute in Columbus, Ohio. Her research interests include pre-college engineering education, informal engineering education, and identity development.

Dr. Rachel Louis Kajfez, The Ohio State University

Dr. Rachel Louis Kajfez is an Associate Professor in the Department of Engineering Education at The Ohio State University. She earned her B.S. and M.S. degrees in Civil Engineering from Ohio State and earned her Ph.D. in Engineering Education from Virginia Tech. Her research interests focus on the intersection between motivation and identity, first-year engineering programs, mixed methods research, and innovative approaches to teaching. She is the principal investigator for the Research on Identity and Motivation in Engineering (RIME) Collaborative.

Dr. Mahnas Jean Mohammadi-Aragh, Mississippi State University

Jean Mohammadi-Aragh is the Director of Bagley College of Engineering Office of Professional Development and Associate Professor in the Department of Electrical and Computer Engineering at Mississippi State University. Through her interdependent roles in research, teaching, and service, Jean is actively breaking down academic and social barriers to foster an environment where diverse and creative people are successful in the pursuit of engineering and computing degrees. Jean's efforts have been recognized with numerous awards including the National Science Foundation Faculty Early Career Development award, the American Society for Engineering Education John A. Curtis Lecturer award, and the Bagley College of Engineering Service award. Jean earned her B.S. and M.S. in computer engineering from Mississippi State University, and her Ph.D. in engineering education from Virginia Tech.

Engineering Students' Negotiation of Identity Congruence

Abstract

Engineering identity has been established as a key predictor of recruitment to and persistence through engineering degree programs. Many students who find that their own identity, the beliefs they hold about who they are and what they want to achieve, is incongruent with their perception of who or what an engineer is ultimately leave engineering programs to pursue other fields of study where the alignment is stronger. However, for a variety of reasons, some students continue to pursue an engineering degree and enter a process of identity negotiation, where they seek to align their personal and professional identities. This negotiation causes adjustment on both sides of the tension to who they believe they are and/or how they make sense of being an engineer.

As a part of a larger study focused on the impact of first-year engineering (FYE) programs on the development of communities of practice and engineering identity, semi-structured interviews were conducted with a group of students in each of the three years following their FYE experience. Using this longitudinal perspective, we focus this paper on five focal students who saw their identities as incongruous to engineering and underwent an individual process of identity negotiation.

We examine the experiences of these students throughout their college experiences and how they negotiated their identity within engineering, as well as provide some insights into causes of identity incongruence driven by systems level institutional choices. The student experiences are used to inform recommendations, particularly aimed at new engineering educators, to support students who find their identity to be misaligned with their perception of engineering.

Introduction

There are persistent calls to graduate more engineers to meet the needs of society today (e.g., [1]-[3]). Yet, engineering struggles to attract and retain enough college-level engineering students to meet the projected needs (e.g., [4]-[6]), with some estimates indicating that nearly half of students who begin an engineering degree do not complete it ([1], [7]). To meet the needs of the future, we must address the barriers that prevent students from choosing to pursue and completing engineering degrees.

One critical factor in recruitment and retention in engineering is engineering identity (e.g., [8], [9]). Identity, as a broad construct, is often based on the work of Erikson [10] and can be thought of as the answer to the question “Who are you?” [11]. A person could answer this question in a myriad of ways considering both their views of themselves as an individual (e.g., [12]) or as a member of a group (e.g., [13]). When considering engineering identity more specifically, we are interested in how people view themselves in relationship to the role of an engineer. We limit this view of identity to scope our work but recognize the plethora of dimensions that impact how individuals see themselves and are impacted by the world.

In this study, identity was operationalized through Communities of Practice (COP) [14], in this case we were particularly interested in the COP of engineering. COPs include three elements: mutual engagement (people within the community interacting and working together); joint enterprise (working together for a common goal); and shared repertoire (shared ways of doing things within the COP and shared resources). Through learning practices, participants move from legitimate peripheral participants to members of the learning experiences, and these experiences impact identity development within community [15].

Prior research has indicated that those students who hold a stronger engineering identity are more likely to persist [9]. Some students find that their own personal identity (the beliefs they hold about who they are and what they want to achieve) is incongruent with their perception of who or what an engineer is, and ultimately, many of those students leave engineering programs to pursue other fields of study where the alignment is stronger. However, for a variety of reasons, some students continue to pursue an engineering degree and enter a process of identity negotiation, where they seek to align their personal and professional identities.

Identity negotiation describes an ongoing process where a person works to shape and express their sense of self in relation to others. According to Holland et al. [16], it is more likely that those who integrate their identity with a particular field will adopt the values of that field and persist. When we consider the COP of engineering, this process of the adopting the field's values likely would occur as the person moves from legitimate peripheral participants to members of the COP. Within engineering, identity negotiation has been studied to better understand the how women negotiate their identity in the workforce (e.g., [17]) and how civil engineering students negotiate their professional identity (e.g., [18]). In each of these cases, participants sought to align how they viewed themselves with regards to the engineering field to find their place there.

In this paper, we share the stories of five focal students who underwent such identity negotiations, found a niche within engineering, and ultimately persisted to graduation. The experiences of these students were used to develop recommendations for engineering educators to support students who may express a misalignment between their personal identity and who or what they view an engineer to be.

Methods

This paper draws from a larger study, where a group of students was followed in the three years following their FYE course. Over this time, we interviewed them once per year to understand the long-term impacts of FYE experiences on community and identity development. For this paper, we focused on the five focal students who underwent identity negotiations and persisted to scope the work.

Context

Data was collected at two, large public universities in the United States, with Institution 1 being in a rural area of the south, and Institution 2 being in an urban area of the Midwest. Both institutions have well-established engineering programs, though their first-year engineering (FYE) experience differ significantly in structure. Institution 1 follows a direct matriculation approach [19], where participants take their FYE course within their chosen major. Institution 2 employs a common first-year structure [19] where all students take the same course, regardless of intended major. During their FYE experience, all students at Institution 2 were considered “pre-majors” and later applied to their desired major(s), though may not be admitted to their first choice.

Participants

Participants in this study were recruited in the fall of the year following their FYE course. A recruitment survey, much of which was derived from the work of Jones et al. [20], was sent to all students who had been enrolled in FYE courses during the 2016-2017 school year. The survey instrument can be found in our previous work [21]. This survey also included descriptive data such as major, any prior tertiary education, and demographics, as well as both Likert scale and open-ended questions regarding community and identity.

Using purposeful sampling to ensure a broad representation of experiences, majors, sex, race, and other factors, 29 participants were initially selected between the two institutions. In this article, we focus on a subset of those students, the five who articulated an identity negotiation throughout their three interviews and yet remained in engineering. Table 1, below, shows their demographics.

Table 1: Focal participant demographics

Participant Pseudonym	Institution	Gender	Major	Race
Laura	1	F	Electrical	Black
Lorie	1	F	Mechanical	White
Thomas	1	M	Industrial	Black
Elroy	2	M	Industrial	White
Sherry	2	F	Mechanical	Asian

Data Collection and Analysis

A series of three semi-structured interviews were conducted in the spring of 2018, 2019, and 2020. These interviews focused on several topics regarding the impact of first-year engineering, engineering identity, and communities. The interviews were audio-recorded and then transcribed. Interviews evolved from year to year to capture participant’s development over time. More specifics regarding the interview protocol can be found in our previous work [22];

however, the key focus of these interviews for this paper is around the question “Are you an engineer?” and the follow-up personalized probing questions, which was asked in each year’s interview. The follow-up probing questions were used to elicit more understanding as to how participants viewed themselves in relation to engineering; what were the personal qualities, experiences, and other factors that factored into their decision of whether or not they were an engineer.

Following the interviews, the interviews were professionally transcribed, and each transcript was reviewed by a researcher for accuracy, before identifying information was removed. Each interview was analyzed using an iteratively developed codebook focused on engineering identity and COP. These codes were initially grounded in previous research, such as Wenger’s COP work [14] and Gee’s identity work [12].

Following coding, a longitudinal memo was developed following the work of Lee et al. [23]. This memo documented each year’s interview, as well as noting changes across time. For more detail on the longitudinal memo development, see our previous work [24]. Similar to the interviews, the memos were developed iteratively through a process of discussion amongst the research team to ensure that the participant’s experiences were accurately portrayed. These memos were used to develop themes across participants at each institution, and across the whole body of participants to identify trends that transcended institutional differences. For additional detail regarding the data analysis, please see our previous work [22].

Positionality and Quality

All three authors hold multiple degrees in engineering, two of these undergraduate degrees were from our study sites. Each has been part of the instructional team, in various capacities, in the undergraduate programs at each institution. Though none of the participants in this study were directly instructed by any of the authors, the authors have worked to shape curriculum and other experiences for undergraduate engineering students.

Though these experiences may bring bias, they also provide important institutional and contextual knowledge of undergraduate engineering programs and how FYE programs and other experiences shape engineering students. They have also worked to support new educators in these programs helping to onboard new hires and support their colleagues in professional development in this domain.

Throughout the project, the authors sought to mitigate any biases by conducting quality checks at every stage of the project, including utilizing researchers outside of the authorship team for additional insight and perspective on the study design, data analysis, and findings. The authors also purposely reflected on their own experiences and how those experiences could influence data analysis to minimize the influence and allow the participants’ viewpoints to drive the findings.

Limitations

The primary limitation to this study is self-selection bias. Though we attempted to recruit and retain students who left engineering in this study, we were unsuccessful. As such, we cannot represent the experiences and stories of those students who ultimately decided (or had the decision made for them) that becoming an engineer was not in their future. While we believe the stories of those who stayed can provide meaningful insight on the identity negotiation process, it is important to acknowledge that we do not have the full picture while reviewing the findings below.

Results & Recommendations.

Students negotiated the meaning of an engineering identity to fit within their personal identity. In this section, we share the data from our study which informed our recommendations, as well as our recommendations to new engineering educators, who are often positioned to support this negotiation. ~~Table 2~~Table-2, below, summarizes the themes which arose from our data and the subsequent recommendations. These themes and recommendations will be further elaborated on in the subsequent sections

Table 2: Summary of themes and recommendations

Theme	Recommendation
Limited awareness of varied engineering career paths can limit engineering identity	Support career exploration that highlights hybrid engineering roles, enabling students to connect their interests and strengths to a broader range of engineering careers.
External family or institutional pressures can impact student persistence and satisfaction in engineering programs	Implement advising practices, student strategies, and program flexibility to reduce institutional barriers and support students navigating parental expectations.
Engineering identity is vulnerable during periods of academic and personal difficulty	Proactively support students during academic or personal setbacks to reinforce confidence, belonging, and persistence in engineering.

Theme 1: Limited Awareness of Varied Engineering Career Paths can Limit Engineering Identity

Across both institutions, participants who remained in an engineering major but struggled to align their personal identity with engineering often sought out alternate engineering pathways or sub-paths. This commonly occurred in conjunction with some form of limitation placed on the participant's choice to pursue engineering. For example, parents may have limited a child by forcing them to major in engineering or universities may have limited choice through highly selective application procedures. Although the participants remained in engineering, they discussed an inability to envision themselves as a traditional practicing engineer. Students often realized (later in their programs) that they do not see themselves as being a traditional, practicing engineer. They then find some type of career path or option where they can use their engineering degrees or backgrounds to their advantage without doing engineering work daily or having the "engineer" title in their occupation. This seems to be more common once students feel they are "in too deep" with their engineering major, as time and potential funds begin to run out. We first highlight the misalignment and sub-paths with Lorie's story. Lorie was able to take the misalignment and capitalize on it to find a unique niche in theater for engineering.

Lorie pursued an alternate path based on her primary career interest in theater. Each time we spoke with her over the final three years of her engineering degree program, Lorie described her passion for music and theater and the arts. Her father is an engineer, and Lorie majored in engineering because she felt pressured by her parents to choose a STEM field. Beyond restricting Lorie to engineering, her parents also limited her choices to a subset of engineering disciplines:

I had heard about [industrial engineering], and I was like, I feel like I might enjoy this. And I told Dad and he said, 'Those are imaginary engineers.' ... And now that I'm in school, I'm like, that's so offensive and I would've really liked that. But back then I didn't

really know anything about it except this Google blurb and so I was like, oh okay, of course. And crossed it off [my list of potential engineering majors]. Since then, I told him that he said that and he was like, 'I don't remember saying that. I think that I was joking.' And I was like, okay, that's definitely what you said, but fine. ... Yeah, and he definitely since then has been like, 'That's just a joke. We give people crap around the office. I would obviously never say that to somebody seriously.' But I always look back and think it wasn't really funny. Even since then, my mom, I think it was like two years ago, was texting me and she was like, 'You know, my friend at work, her son is an industrial engineer and that sounds like something you might enjoy.' And I was like, yeah, before it was too late to change my major, I might've enjoyed that.

Lorie kept thinking that she would like engineering more as she enrolled in higher-level engineering classes or when she interned and experienced real-life engineering applications. However, she had those experiences, and they did not motivate her for an engineering career. Instead, she grew closer to the theater community as she participated in building sets and other theater activities. As a fourth-year engineering major, Lorie described her plans to pursue a Masters in Fine Arts for technical directing, stage automation, or scenic technology. She described an engineering identity that was linked to those three areas of her theater work.

I feel like I feel more like an engineer working in the theater than I did before... Because I do feel like I have a lot of times that I'll go in and it'll be like, "Okay we want to make this, how do we do that?" And then I feel like I'm able to be like, "Okay, well we made this other thing and that kind of worked." I guess just I feel more able to creatively problem solve in the way that I feel like an engineer's supposed to... Because I feel like even people who work in the traditional STEM fields have to be creative.

Though Lorie is pursuing a future career path in theater, she did recognize how she could apply her engineering skills within the field of theater, such as being interested in welding in terms of scene design. She used the phrase “entertainment engineering” to merge the two fields.

Thomas followed a similar path, describing his desire to enter technical engineering sales jobs after he earned his bachelor's degree. In his final interview, Thomas shared how he struggled to find a place for himself in engineering:

There's just a lot of realizations that's been happening over a year... What my interests are and how I can utilize my degree to the fullest. So that's basically being within a Sales Engineer, being able to market the product, but know the technical aspect of it as well. So I can still use my degree, but I can focus more on what I like doing; business communication... I guess it started off as like, "Okay, what do I truly want to do?" And I just realized that the nitty gritty innovation with engineering wasn't the best route for me. So I started looking into other routes and I had a friend at school who did an internship as a Sales Engineer. And so he told me a little bit about his story and some of the things that he did. And that's something that really strike something in me. I was like, "Okay, I feel like that's a[n] area I can go in and I can be more productive and more efficient." So I started doing more research and come to find out this exactly what I'm doing. And also I want to go to grad school and my MBA as well.

Lorie and Thomas's stories serve as examples of the experiences which lead to our first recommendation, which will be discussed in more detail below: ***Support career exploration that highlights hybrid engineering roles, enabling students to connect their interests and strengths to a broader range of engineering careers.***

Theme 2: External Family or Institutional Pressures Can Impact Student Persistence and Satisfaction in Engineering Programs

Especially in situations where participants felt trapped in engineering, we noted that the struggle with engineering identity and personal identity alignment eclipsed the value of a positive, authentic, hands-on engineering experience. Laura's story provides an example of this. In her first interview, Laura described a strong desire to switch to a business major. In her second interview that occurred during her third year, Laura highlighted her enjoyable electrical engineering co-op work, which was focused on selling and designing pole lights for homes and businesses. However, she clearly articulated a feeling of being trapped in engineering. Directly following Laura's conversation about her co-op experience, the interviewer reminded Laura about her comments during her first interview regarding changing her major and then asked Laura if she was still thinking about a major change. Laura responded that she still had a strong desire to transfer to business despite her "great co-op" but would not change because of her mother's influence:

I'd still love to do that. I'd do it. [...] I'm completely open to business, but my mom shut me down, multiple times. So, I'm just going to drop, I'm dropping it. Dropping it. I need to graduate and then go work for this company I'm working for right now, until I move out. I'll go to whoever's going to hire me. But I've got a really good chance at this company right now, and the starting pay's amazing. So, it'll be worth it. And I'm only going to stay for about four years.

Laura stayed in her engineering program and planned to work in engineering because she felt trapped. However, she indicates she will continue to work in engineering only for a set period, and once she is less dependent on her parents, she will leave engineering.

Elroy also experienced a struggle with engineering and personal identity alignment. During our initial interview, we spent a significant amount of time discussing his major and the process of applying to majors at Institution 2. When asked if he was an engineer, Elroy responded "*I am an engineer. I'm an industrial and systems engineer now.*", which on the surface seemed to indicate a strong identity tied to his discipline. However, upon further discussion, it became clear that industrial and systems engineering (ISE) was not his first choice in major, and it took significant identity negotiation to reach his initial statement. Elroy enrolled at Institution 2 as a mechanical engineering (ME) pre-major and applied to ME as his first choice of major. However, he was not admitted to ME, an experience which he described himself as "*bitter*" about. Elroy even considered switching universities or out of engineering all together as a response to not being admitted to ME. He ultimately was admitted to ISE and worked to align his personal identity with his engineering identity, ultimately saying in his second interview "*I really got into the ISE major, which has been really awesome. And, I've really liked it.*" These participants experienced an internal struggle but ultimately found a path forward. These student experiences lead to our second recommendation, which will also be discussed below:

Implement advising practices, student strategies, and program flexibility to reduce institutional barriers and support students navigating parental expectations.

Theme 3: Engineering Identity is Vulnerable During Periods of Academic and Personal Difficulty

For some students, they have long viewed themselves as the type of people who would become engineers and may even enter college with a specific engineering career in mind.

However, this identity can be threatened by a myriad of factors, including challenging coursework, learning more about opportunities within the field, or other personal factors.

Sherry made it clear in her first interview that her goal was to work in the medical device industry and had applied to and been accepted in the biomedical engineering program.

I went in as biomedical freshman year, because at the [Private University] program, it was really cool, because each week was focused on a different type of engineering. And it was biomedical, optical, and audio. And I don't know, for the biomedical one, it was really cool, because there was this professor who had this device that...And it was just so fascinating, and I loved it, and that's kind of what I want to ... Like that type of device, or I just think the brain is so awesome.

Sherry described herself saying “I've always been like a STEM type of person.” and shared that “I've actually wanted to be an engineer since like fourth grade because I did like, an invention camp”. However, during her first interview, when asked if she was an engineer, she revealed that she had considered leaving engineering:

I've definitely, last semester at least, I was definitely questioning that, because all my classes were the same, and I just was not enjoying it at all. I was actually thinking of dropping engineering and doing something else. I didn't know what. I just was like, "I've got to get out"

During her second interview, Sherry shared that she had switched majors twice since we had last spoken. She switched first to mechanical engineering due to her perception of the likelihood that she would get a biomedical job:

And someone was like, "It's a lot easier," Or not easier, but, "If you want to do industry, and don't want to do med school, then mechanical is where you want to go." And then get the bio part later on, or you can pick that up when you need to, and then Mech-E is much more versatile. So that's why I'm Mech-E

She then switched to welding engineering in her third year, as she sought to negotiate her view of engineering and engineering work with her views of herself:

I've always thought I was a smart person and then I'm questioning that because these grades and getting below average on stuff was like that's not how I usually do and being surrounded by engineers, because I was in the learning community. It was good and bad. You could get help with maybe certain things and there's always that's how they sell the learning community oh, you can ask someone down the hall about a problem. But also we were all stressed out and we all kept feeding off of that stress.

In our third interview, Sherry had comfortably settled into welding engineering and held a more positive view of her prospects as an engineer. She participated in undergraduate research and internships to prepare her for her future career, saying “This past summer, I stayed in [large midwestern city] and did research with [professor]. And I really enjoyed it”. At the time we spoke with Sherry, she had landed a summer internship and still planned to go into the medical device field. She was debating between graduate school and entering industry. She doesn't yet call herself an engineer, but feels she is close:

I think once I get the job I'm for sure an engineer, but I felt like there was a big hump that I had to go. I think last time when we met, it felt like I still had obstacles in my way to becoming an engineer. I am not quite an engineer yet, but I don't feel like I have many obstacles.... I think I was still questioning if I could do the engineering program just in general because at that point, I think I had just switched into welding or something. So that it was like I was in the major I believe, but I hadn't taken any classes really. Or I was

in the middle of classes so I didn't really have a good gauge of how it was gonna go. And my experience with engineering classes had been rough which led to changing the majors and everything. So it was like I knew I had struggled in the past. And so having the foot in the door with being in my major was great, but would I be able to succeed in the major? I wasn't sure cuz I was still like, could I do engineering? Now, I'm 99.5% positive that I can do it.

Sherry came into her engineering program with a clear idea of how she would become an engineer in the medical device field, however, this path became untenable to her. She entered a process of identity negotiation and adjustment of her planned path, ultimately finding alignment between the subfield of medical devices and her identity.

Returning to Thomas, he experienced a similar challenge to his initial goal of becoming an engineer, which required a period of negotiation to. In his final interview, Thomas reflected on his experiences saying:

Honestly I just didn't feel as if I was equipped or adequate enough to be great in a lot of areas. Okay, so for engineering, I didn't think at the time that I was able to be a[n] engineer because my ability to learn is, I feel like, it's slower than others or the way I learn is different from others and some people can catch it like right there, as soon as it's presented and understand it. And for me it wasn't. I guess my confidence was low on that, because I just couldn't do it their way and somehow saw how other people went through classes, I couldn't. So just as a[n] engineer major, I was like, "What if I'm not cut out for this or what if I'm not going to be the best engineering?" Things like that.

As with Sherri, one factor in Thomas' identity negotiation was a consideration of if he was smart enough to be an engineer. These experiences lead to our final recommendation, which will again be discussed below: ***Proactively support students during academic or personal setbacks to reinforce confidence, belonging, and persistence in engineering.***

Discussion of Recommendations

When students experienced a mismatch between their engineering identity and their personal identity, they often entered in a negotiation with themselves (and sometimes others) to determine their next steps. For many of our participants, the resultant solution to the negotiation was that the sub-path or subfield in engineering became a central part of their engineering identity. Participants with misaligned engineering and personal identities vocalized an internal struggle but ultimately found a path forward by incorporating elements of their personal identity into their engineering identity and were retained in engineering.

The notion of struggle with one's identity within a learning group can be explained through identity congruence [25]. Extending the community of practice work related to identity by Wenger [14], Hughes [25] describes identity congruence as a negotiation between oneself and the identities available within a learning group. Given the often homogeneity of an engineering student body, the available identities are often limited and students, especially those from underrepresented groups, must enter a negotiation to determine if and how they belong. While a continued mismatch can lead to students being stuck at the margins of a learning group [25], all the participants in this study who described identity mismatches persisted in engineering, and they all found other available identities within the engineering domain that aligned with their views of themselves. As educators, we must be attuned to this potential misalignment and help students navigate this negotiation.

Recommendation 1: Support career exploration that highlights hybrid engineering roles, enabling students to connect their interests and strengths to a broader range of engineering careers.

For some students, such as Lorie, the struggle to view themselves as an engineer may lie within their personal interests. These students described other, non-engineering interests (such as theater for Lorie) that they were unable to fully pursue. Godwin et al. [26] include interest as a key component which mediates engineering identity and thus engineering as a career choice. In their work, it was found that performance or competence beliefs without interest and recognition in a field negativity predicts subject-related identity. While these students may have been capable of acting as an engineer, they had interests elsewhere and thus struggled to develop an engineering identity.

Engineering educators may be able to support this identity negotiation by helping students identify careers and other opportunities where their personal interests and engineering intersect, as Lorie eventually found for herself with technical theater. We know from existing research that pre-college students hold inaccurate views of engineers and engineering (e.g., [27], [28]) and that some of these views persist as students enter engineering degree programs (e.g., [29]). To make matters more complicated, the public also does not typically understand the engineering profession. A 2017 survey of the Canadian public indicated that only 14% of people indicated they were “very familiar” with engineering, compared to 49% of people for doctors, and 40% of people for nurses. Following a similar trend, 55% percent of people indicated that they were “aware but not familiar”, “not familiar” or “don’t know” with regards to engineering, compared to only 24% of respondents for doctors and 23% of respondents for nurses [30]. This means that engineering educators may be the only group of people that can support students in the exploration of engineering outside of the stereotypical positions, such as in the automotive industry. This might be done on an individual level through connecting students with alumni or other people in your network, or through opportunities for all students to be exposed to a range of careers through alumni panels, in-class activities, or field trips (e.g., [31]-[33])

Recommendation 2: Where possible, support student agency in career determination.

We also noted that the misalignment between engineering identity and personal identity was commonly related to restrictions placed on a participant’s choices or sense of agency. For multiple participants, this limit was placed by parents. While institutions cannot control how parents limit choices, engineering administrators and faculty can be mindful of these impacts when advising students or designing student support programs and activities. More specifically, direct matriculation programs may force students into majors based on limited choices because the choice of major must happen before even coming to college, but ensuring students learn about their major early, such as within a first-year engineering course, and keeping processes to change between engineering majors simple and straightforward could support students who want to switch. Similarly, common first-year programs with enrollment limits for certain majors may reduce options once students enter their second years. These limits, whether family or institution related, impact students’ agency which is key for identity development and growth (i.e., people must be able to choose who they are in spaces for identity development to take place) [16]. Additional research must be conducted to understand the impact of agency and engineering identity within the first year and beyond.

Recommendation 3: Proactively support students during academic or personal setbacks to reinforce confidence, belonging, and persistence in engineering.

Finally, we noted that identity negotiation was often initiated by academic challenges. Participants expressed phases akin to “I don’t know if I’m smart enough to be an engineer”. Many studies have indicated that engineers are generally viewed as intelligent and good at math and science (e.g., [34]-[36]), and more recent work indicates that students’ engineering identity is intertwined with their view of themselves as someone who is smart (e.g., [37]-[39]). Research by Kramer et al.[40] found 11 beliefs that engineering students held about being smart in an engineering context, including achievement with little effort, being born with an innate ability, solving complex problems, and working efficiently. It is then, perhaps, unsurprising that academic challenges, such as perceived slow uptake of material or less than desirable grades, as Thomas and Sherry described could lead to students questioning their place in engineering.

Engineering educators may inadvertently reinforce these beliefs in their classrooms. Kramer et al. [40] recommended three practices in the classroom: 1) consider critically how assessment practices enact particular values, 2) normalizing effort and the role of prior experiences in learning and 3) reflect on the discourse of engineering and how that aligns with values being enacted in the classroom. Considering what we communicate about who an engineer is, both implicitly and explicitly, can help engineering educator begin to support students undergoing this kind of identity negotiation.

Conclusions & Future Work

Many of the participants encountered a misalignment between their engineering and personal identities. The misalignment was often related to limits on career choice and led to negotiations between their engineering identity and personal identity. Finding compatibility between misaligned identities appears to be positively related to student retention and is something attuned engineering educators may be able to support. We recommend establishing opportunities for students to explore engineering careers that align with their personal interests, working to reduce institutional barriers, and supporting students during academic and personal challenges. These, and other actions, may help support engineering identity negotiation and development for those struggling to see themselves in the world of practicing engineers. Future work should focus on the impact of supports put in place to assist students with identity negotiations.

Acknowledgements

This material is based upon work supported by the National Science Foundation under Grant Nos. 1664264 and 1664266. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation. We would like to acknowledge and thank all of the participants for sharing their stories with us and continuing to engage throughout the project. Additionally, we would like to thank all of the researchers who have contributed to this project throughout its lifespan.

References

- [1] President's Council of Advisors on Science and Technology, "Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering and mathematics," Washington, D.C., 2012. [Online]. Available: https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_2-25-12.pdf
- [2] President's Council of Advisors on Science and Technology, "Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Tehcnology, Engineering, And Mathematics."
- [3] National Academies of Sciences, Engineering, and Medicine, "Rising Above the Gathering Storm," 2007. [Online]. Available: <https://www.nationalacademies.org/our-work/rising-above-the-gathering-storm-energizing-and-employing-america-for-a-brighter-economic-future>
- [4] U.S. Bureau of Labor Statistics, "Architecture and Engineering Occupations." Accessed: Jan. 14, 2026. [Online]. Available: <https://www.bls.gov/ooh/architecture-and-engineering/home.htm>
- [5] K. Moody, "Companies need engineering talent. But where are the engineers?," HR Drive. Accessed: Nov. 14, 2026. [Online]. Available: <https://www.hrdrive.com/news/companies-need-engineering-talent-but-where-are-the-engineers/731982/>
- [6] A. Kodey, J. Bedard, J. Nipper, N. Post, S. Lovett, and A. Negreros, "The US Needs More Engineers. What's the Solution?," BCG. Accessed: Jan. 14, 2026. [Online]. Available: <https://www.bcg.com/publications/2023/addressing-the-engineering-talent-shortage>
- [7] Xianglei Chen, "STEM Attrition: College Students' Paths Into and Out of STEM Fields," National Center for Education Statistics, Institue of Education Sciences, US Department of Education, Washington, D.C., NCES 2014-001, 2013.
- [8] H. M. Matusovich, R. A. Streveler, and R. L. Miller, "Why Do Students Choose Engineering? A Qualitative, Longitudinal Investigation of Students' Motivational Values," *J. Eng. Educ.*, vol. 99, no. 4, pp. 289–303, Oct. 2010, doi: 10.1002/j.2168-9830.2010.tb01064.x.
- [9] T. Beam, O. Pierrakos, J. Constantz, A. Johri, and R. Anderson, "Preliminary Findings On Freshmen Engineering Students' Professional Identity: Implications For Recruitment And Retention," in *2009 Annual Conference & Exposition Proceedings*, Austin, Texas: ASEE Conferences, Jun. 2009, p. 14.968.1-14.968.12. doi: 10.18260/1-2--5112.
- [10] E.H. Erikson, *Identity: youth and crisis*, 1st ed. New York, NY, 1968.
- [11] V. L. Vignoles, S. J. Schwartz, and K. Luyckx, "Introduction: Toward an integrated view of identity," in *Handbook of Identity Theory and Research*, vol. 1, 2011, pp. 1–27.
- [12] J. P. Gee, "Chapter 3 : Identity as an Analytic Lens for Research in Education," in *Review of Research in Education*, vol. 25, 2000, pp. 99–125. Accessed: May 18, 2022. [Online]. Available: <http://journals.sagepub.com/doi/10.3102/0091732X025001099>
- [13] B. E. Ashforth and F. Mael, "Social Identity Theory and the Organization," *Acad. Manag.*, vol. 14, no. 1, pp. 20–39, Jan. 1989.
- [14] E. Wenger, *Communities of practice: Learning, meaning, and identity*. Cambridge university press, 1999.
- [15] J. Lave and E. Wenger, *Situated learning: Legitimate peripheral participation*. Cambridge university press, 1991.

- [16] D. Holland, W. Lachicotte Jr, D. Skinner, and C. Cain, *Identity and agency in cultural worlds*.
- [17] D. M. Hatmaker, "Engineering Identity: Gender and Professional Identity Negotiation among Women Engineers," *Gend. Work Organ.*, vol. 20, no. 4, pp. 382–396, Jul. 2013, doi: 10.1111/j.1468-0432.2012.00589.x.
- [18] C. McCall, L. D. McNair, and D. R. Simmons, "Advancing from outsider to insider: A grounded theory of professional identity negotiation in undergraduate engineering," *J. Eng. Educ.*, vol. 110, no. 2, pp. 393–413, Apr. 2021, doi: 10.1002/jee.20383.
- [19] X. Chen, C. Brawner, M. Ohland, and M. Orr, "A Taxonomy of Engineering Matriculation Practices," in *2013 ASEE Annual Conference & Exposition Proceedings*, Atlanta, Georgia: ASEE Conferences, Jun. 2013, p. 23.120.1-23.120.13. doi: 10.18260/1-2--19134.
- [20] B. D. Jones, M. C. Parette, S. F. Hein, and T. W. Knott, "An Analysis of Motivation Constructs with First-Year Engineering Students: Relationships Among Expectancies, Values, Achievement, and Career Plans," *J. Eng. Educ.*, vol. 99, no. 4, pp. 319–336, Oct. 2010, doi: 10.1002/j.2168-9830.2010.tb01066.x.
- [21] A. Clark, R. Kajfez, and M. J. Mohammadi-Aragh, "Work in Progress: Baseline Survey about Community and Identity," in *2018 ASEE Annual Conference & Exposition Proceedings*, Salt Lake City, Utah: ASEE Conferences, Jun. 2018, p. 31271. doi: 10.18260/1-2--31271.
- [22] M. J. Mohammadi-Aragh, R. L. Kajfez, A. Clark, and S. Sassi, "Engineering Identity Formation across the Undergraduate Years," *Int. J. Eng. Educ.*, vol. 41, no. 6, pp. 1616–1630, 2025.
- [23] D. Lee *et al.*, "Enhancing Research Quality through Analytical Memo Writing in a Mixed Methods Grounded Theory Study Implemented by a Multi-Institution Research Team," in *2019 IEEE Frontiers in Education Conference (FIE)*, Covington, KY, USA: IEEE, Oct. 2019, pp. 1–7. doi: 10.1109/FIE43999.2019.9028469.
- [24] C. Wallwey *et al.*, "Longitudinal Memos Investigating First-year Engineering Pathways," in *2020 ASEE Virtual Annual Conference Content Access Proceedings*, Virtual On line: ASEE Conferences, Jun. 2020, p. 34932. doi: 10.18260/1-2--34932.
- [25] G. Hughes, "Identity and belonging in social learning groups: The importance of distinguishing social, operational and knowledge-related identity congruence," *Br. Educ. Res. J.*, vol. 36, no. 1, pp. 47–63, Feb. 2010, doi: 10.1080/01411920902834167.
- [26] A. Godwin, G. Potvin, Z. Hazari, and R. Lock, "Identity, Critical Agency, and Engineering: An Affective Model for Predicting Engineering as a Career Choice," *J. Eng. Educ.*, vol. 105, no. 2, pp. 312–340, Apr. 2016, doi: 10.1002/jee.20118.
- [27] B. Fralick, J. Kearn, S. Thompson, and J. Lyons, "How Middle Schoolers Draw Engineers and Scientists," *J. Sci. Educ. Technol.*, vol. 18, no. 1, pp. 60–73, Feb. 2009, doi: 10.1007/s10956-008-9133-3.
- [28] R. Carr and H. Diefes-Dux, "Change in Elementary Student Conceptions of Engineering Following an Intervention as Seen from the Draw-an-Engineer Test," in *2012 ASEE Annual Conference & Exposition Proceedings*, San Antonio, Texas: ASEE Conferences, 2012, p. 25.299.1-25.299.12. doi: 10.18260/1-2--21057.
- [29] R. Fries and R. Krauss, "An Analysis of First-Year Students' Changing Perceptions of Engineering Design and Practice," in *2014 ASEE Annual Conference & Exposition Proceedings*, Indianapolis, Indiana: ASEE Conferences, Jun. 2014, p. 24.150.1-24.150.9. doi: 10.18260/1-2--20041.

- [30] Engineers Canada and Innovative Research Group, "Public Perception of Engineers," Mar. 2017. Accessed: Jan. 14, 2026. [Online]. Available: <https://engineerscanada.ca/sites/default/files/public-perceptions-of-engineers-and-engineering.pdf>
- [31] M. James, K. Hodges, and J. Lo, "Enhancing Student Perceptions of Engineering Disciplines through Showcasing of Career Paths," in *2019 ASEE Annual Conference & Exposition Proceedings*, Tampa, Florida: ASEE Conferences, Jun. 2019, p. 32750. doi: 10.18260/1-2--32750.
- [32] M. Kenny, O. Pierrakos, and M. O'Connell, "Infusing the Liberal Arts in First-Year Engineering: A Module on History, Professional Identity, and Courage," in *2021 ASEE Virtual Annual Conference Content Access Proceedings*, Virtual Conference: ASEE Conferences, Jul. 2021, p. 37336. doi: 10.18260/1-2--37336.
- [33] K. Mohd-Yusof, F. Phang, A. Sadikin, S. A. Helmi, and M. J. Kamaruddin, "Determining the Effect of an Engineering Overview Assignment on First-Year Students," in *2014 ASEE Annual Conference & Exposition Proceedings*, Indianapolis, Indiana: ASEE Conferences, Jun. 2014, p. 24.382.1-24.382.15. doi: 10.18260/1-2--20273.
- [34] National Academy of Engineering, *Changing the conversation: Messages for improving public understanding of engineering*. Washington, D.C.: National Academies Press, 2008.
- [35] E. Godfrey and L. Parker, "Mapping the Cultural Landscape in Engineering Education," *J. Eng. Educ.*, vol. 99, no. 1, pp. 5–22, Jan. 2010, doi: 10.1002/j.2168-9830.2010.tb01038.x.
- [36] N. Sochacka, J. Walther, J. Wilson, and M. Brewer, "Stories 'Told' about engineering in the Media: Implications for attracting diverse groups to the profession," in *2014 IEEE Frontiers in Education Conference (FIE) Proceedings*, Oct. 2014, pp. 1–9. doi: 10.1109/FIE.2014.7044009.
- [37] R. Kajfez, A. Kramer, B. Braaten, and E. Dringenberg, "Am I smart enough to be an engineer? How undergraduate engineering students articulate their identities," *J. Eng. Educ.*, vol. 114, no. 3, p. e70005, Jul. 2025, doi: 10.1002/jee.70005.
- [38] B. Braaten, E. Dringenberg, A. Kramer, and R. Kajfez, "You're an Engineer? You Must Be Really Smart! A Theoretical Discussion of the Need to Integrate 'Smart' into Engineering Identity Research," *Stud. Eng. Educ.*, vol. 4, no. 2, pp. 22–37, Aug. 2023, doi: 10.21061/see.86.
- [39] E. Dringenberg, A. Kramer, and A. R. Betz, "Smartness in engineering: Beliefs of undergraduate engineering students," *J. Eng. Educ.*, vol. 111, no. 3, pp. 575–594, Jul. 2022, doi: 10.1002/jee.20463.
- [40] A. Kramer, R. L. Kajfez, and E. Dringenberg, "Ways of Being Smart in Engineering: Beliefs, Values, and Introductory Engineering Experiences," *Int. J. Eng. Pedagogy IJEP*, vol. 14, no. 1, pp. 129–148, Jan. 2024, doi: 10.3991/ijep.v14i1.41633.