Engineering Identity and Smartness Identity as They Relate to Women's Participation in Engineering

Cassie Wallwey, Emily Dringenberg, Bailey Braaten, Yiqing Li, and Rachel Kajfez

Abstract*—*Contribution: **This study examined the role of the engineering and smartness identities of three women as they made decisions about their participation in engineering majors. In addressing the under-representation of women in engineering, particularly in electrical engineering and computer science fields where they have been extremely under-represented, it is important to consider engineering identity as it has been shown to be an important component of major selection and persistence.**

Background: **Smartness is inextricably linked to engineering and prior work has shown that identifying as smart is salient to students who choose engineering majors. However, the relative roles of students' engineering and smartness identities as they relate to academic decision making and persistence in engineering is not well understood.**

Research Question: **How do engineering identity and smartness identity relate to women's decisions about choosing engineering majors in the instances of joining engineering, changing engineering major, and leaving engineering?**

Methodology: **Data were collected from a series of three interviews with three different women. Data condensation techniques, including writing participant summary memos and analytic memos, focused on detailing participants' academic decisions, engineering identity, and smartness identity were used for analysis. Data visualization was used to map the women's engineering identity and smartness identity to their academic decisions related to their majors.**

Findings: **The findings indicate the participants' smartness identity was salient in the initial decision to matriculate into engineering, both their engineering and smartness identities remained stable as they persisted in or left engineering. And reveal complex interactions between these identities and decision making.**

***Index Terms*—Decisions to major in engineering, engineering identity, qualitative engineering education research, smartness, women in engineering.**

I. Introduction

WOMEN'S under-representation in engineering has been a persistent trend for decades. While women earned more postsecondary degrees than men in general [1]; only 23.6 percent of engineering bachelor's degrees were awarded to women in 2021 [2]. Within engineering, the percentage of undergraduate degrees awarded to women also varies by discipline, with only about 15% of electrical engineering degrees, 15% of computer engineering degrees, and 20% of computer science degrees being earned by women [2].

Researchers have identified external factors that relate to women's decisions to major in engineering. For example, women are vastly under-represented in faculty ranks across the United States [2] which leads to a lack of women as faculty role models and mentors to female engineering students, which can discourage women from choosing or persisting in engineering majors [3], [4]. The masculine culture of engineering is also understood to not allow women to identify simultaneously as women and as engineers [5], [6]. Marginalization experiences, such as these can result in unsatisfactory educational experiences for women and decisions to leave engineering [7], [8], [9].

Engineering identity has been shown to be an important component of major selection and persistence in engineering for all students [10], [11], [12]. Additionally, being identified as smart in school settings can broaden or limit students' beliefs, identities, and academic decisions [13], [14], [15]. Yet, there is a gap in understanding how women's decisions to participate in engineering relate to their engineering identity and identification as smart. This research study addresses how engineering identity and smartness identity relate to women's decisions to select engineering majors and decisions to join engineering, switch majors within engineering, and leave engineering all together.

Manuscript received 10 December 2022; revised 4 October 2023; accepted 22 January 2024. Date of publication 29 February 2024; date of current version 9 April 2024. This work was supported by the National Science Foundation under Grant 1920421. *(Corresponding author: Cassie Wallwey.)*

This work involved human subjects or animals in its research. Approval of all ethical and experimental procedures and protocols was granted by the The Ohio State University Office of Research's Institutional Review Board.

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Digital Object Identifier 10.1109/TE.2024.3359534

II. Background

A. Engineering Identity

One factor that influences students' decision to major in engineering and their retention in the field is their engineering identity. Engineering identity is recognized as both a social and an individual construct; a person develops their individual engineering identity within social settings and through social interactions [16], [17]. Therefore, engineering identity development is a combination of 1) recognizing oneself as an engineer and 2) being recognized by others as an engineer. Researchers have also shown that identity can be a predictor of engineering career choice for students [10]. Additionally, researchers have indicated engineering identity can be a predictor of persistence in engineering majors [11].

While it has been established that engineering identity matters in decisions related to majoring in engineering, fewer studies address engineering identity as it relates to or intersects with other facets of identity, particularly for underrepresented students, such as the identities of women [17] or other marginalized identities like race and ethnicity [18]. Among engineering identity researchers who have explicitly investigated women's engineering identities, there has been a consensus that for them, engineering identity is entangled with other aspects of identity, particularly gender [18]. For example, women have to prove themselves with regard to their technical engineering identity and gender identity in ways different than their male counterparts [19], and that women often embrace multiple identities when navigating their engineering identity and gender stereotypes [20], [21]. The unique contribution of this work is the simultaneous investigation into two different student identities simultaneously—neither sociodemographic—but instead, both are related to the ontology of what it means to participate in engineering and be an engineer.

B. Smartness Identity

In the context of school and education, smartness identity is always salient. Smartness identity is something that is constructed in social settings, like school [22], [23]; by participating in education, students develop their smartness identity relative to others [22], [24]. Students' identities as more or less smart than others are based on social comparisons (e.g., which students get the highest grades, which students participate most in class, which students get their assignments completed most quickly, etc.) [25]. Ultimately, students develop their identities as smart relative to others based on sociocultural influences as well as their own individual agency [22], [26].

The general culture and practices of STEM education systems function to identify the "best" students and often push "the rest" of the students out [9], and academic performance/ability is often associated with smartness and used to distinguish and develop a hierarchy among students [22]. Smartness identity is particularly salient in the experience of engineering students because engineering students and engineers are often recognized by others as smart [27], [28]. A specific example is the fact that students generally believe that no other college major could be as difficult as engineering [29]. The smartness identity of engineering students is impactful beyond the perceptions and labels of others as well, as researchers have shown that identifying as smart is related to engineering undergraduate students' development of their own engineering identity and feelings of belonging in engineering [30], [31].

Theoretical work has been published making the case for the intentional integration of smartness and smart identities into engineering identity research given the central role of smartness identity in how students experience undergraduate engineering education [32]. Given the importance of engineering identity to students' selection of and persistence within engineering programs there a clear need to address the gap in understanding regarding how smartness identity and engineering identity intersect and influence women's decisions of majoring in engineering and their persistence in the field. For many years, STEM fields have struggled to attract and retain women—unintentionally filtering women out of STEM spaces at higher rates due to complex interactions between cultural beliefs and expectations, as well as educational systems and structures [33]—limiting who shows up in engineering higher-education spaces. Researchers have demonstrated how female students are less likely to be labeled as gifted in precollege education than their white male peers [22]; therefore, they are less likely to be institutionally recognized as smart.

Once women are in STEM programs, any setbacks they experience are more likely to be attributed to their own internal factors or abilities compared to their male peers' setbacks—which are more likely to be attributed to external factors unfavorable toward them or uncontrollable by them [34]. Additionally, researchers have shown that the fields that are perceived to require innate intelligence or abilities, such as physics and engineering, are those with the lowest representation of women [35].

The gendered nature of engineering identity and smartness identity make it essential to understanding how these identities are salient for women's decisions to participate or not in engineering majors in an effort to further the recruitment and retention in of women in engineering programs.

III. Research Question

This study examined the experiences of three women related to their participation in engineering by answering the following research questions.

1) How do engineering identity and smartness identity relate to women's decisions regarding pathways into and through engineering?
2) How are engineering identity and smartness identity related in women's decisions regarding pathways into and through engineering?

IV. Methods

A. Context

This manuscript was inspired and informed by a subset of data collected as a part of a larger project investigating beliefs and identities related to smartness and engineering. Students were recruited from different sections of the same first-year engineering course offered at different institutional contexts: a large Midwestern University, several smaller satellite campuses associated with the university, and a local community college in the same city. Additionally, this study was conducted from 2020 to 2021 during the COVID-19 pandemic. Therefore, participants experienced their primary mode of instruction as online courses during the semesters of this study. These contexts are relevant when considering the transferability of the findings of this study, especially given that identity is socially constructed and the social dynamics of online and in-person learning differ.

TABLE I
DESCRIPTIONS OF THE THREE RESEARCH PARTICIPANTS

Participant Pseudonym	Participation Decision	Additional Details
Anna	Joined engineering	Changed major from finance to electrical engineering after one year in The College of Business
Lynn	Switched majors within engineering	Joined chemical engineering at the end of first year. In second year switched to mechanical engineering. At the end of second year switched to electrical engineering.
Emma	Left engineering	Joined computer science engineering at the end of first year and in second year changed major to video game design in the College of Arts and Science.

B. Participants

This manuscript leverages data generated with three women across a series of three interviews each. These women were purposefully selected to answer the research questions, not to broadly represent the engineering population, but because individually they each represented three distinct cases of a decision-making pattern for their participation in engineering: 1) joining engineering; 2) switching majors within engineering; and 3) leaving engineering. Provided is an initial snapshot into each woman's unique participation trajectory in engineering in Table I; however, the relationships between their engineering and smartness identities and their decisions related to participation in engineering are explored in more depth and used to answer the research questions in the Findings section.

C. Data Collection

Data collection consisted of a series of three semi-structured, one-on-one, 60-min interviews between each participant and a member of the research team. Example questions from all three interviews are provided in Appendix Table II. The first interview took place in the spring semester of 2019 and 2020 academic year, when the participants were in the first year of their undergraduate engineering education. The first interview consisted of questions designed to get a general understanding of students' beliefs about smartness and engineering along with their ways of identifying as smart and as an engineer.

Based on preliminary analysis of the first set of interview transcripts, the second interview protocol was generated and used to conduct the next interview with the same participants during the autumn semester of 2020 and 2021 academic year. In this interview, students were asked to provide a copy of their unofficial academic transcript, which was used as a guide during the interview for questions designed to understand academic decisions (e.g., course selection) and how those decisions related to their engineering and smartness identities.

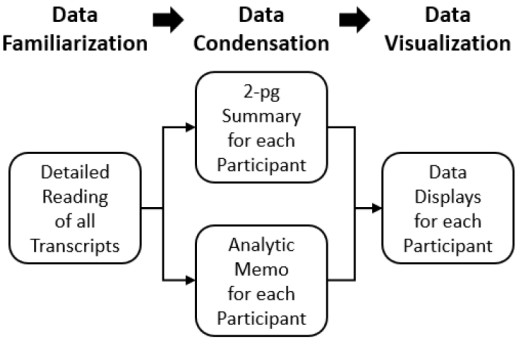

Fig. 1. Progression of data analysis in this study.

The second interview also included questions about how their grades in classes related to their identity as smart and as an engineer.

After additional analysis of the transcripts from the first two interviews, the third interview protocol was generated and used to conduct a final interview with each participant during the spring semester of 2020 and 2021 academic year. This interview protocol was designed to solicit data about how smartness had functioned in the participants' lives both prior to coming to college and in their engineering courses.

D. Data Analysis

The audio recordings from each interview were transcribed by a professional service, checked by the research team for accuracy, and cleaned of identifying information before data analysis. Fig. 1 shows the progression of the analysis for this study.

Data familiarization was conducted by reading all participant transcripts in detail. Then, the data was condensed in two separate ways, each with a specific focus. The first data condensation consisted of creating two-page participant summaries of information about each participant's background, experiences, identities, and beliefs about what it means to be smart and an engineer. One member of the research team created the initial two-page summary for each participant, and a second member of the research team was responsible for a validity check until consensus was reached. The second data condensation was the creation of analytic memos for each participant with more detailed information about each participant's identities as well as the decisions they made regarding their participation in engineering [36]. Two members of the research team created separate analytic memos for each participant, these two separate memos were then compiled into a single analytic memo by a research team member as a validity check. Below are examples of prompts that were addressed in the analytic memos.

Engineering and Smartness Identities:

1) How does the participant describe themselves as an engineer and as smart in each interview?
2) How was smartness identity salient in their decisions? How was engineering identity salient in their decisions?

After both forms of data condensation were complete, data visualization was done by creating data displays for each

participant [36]. These data displays functioned to combine and map participants' engineering participation decisions to their engineering and smartness identities. Interpretation of the final data displays served to answer the research question for each instance of joining, switching majors within engineering, or leaving engineering and how engineering identity and smartness identity related to their decisions.

E. Quality, Trustworthiness, and Limitations

Many steps were taken to ensure quality and trustworthiness of the qualitative data analysis. Data condensation and visualization closely followed recommendations and processes published and widely recognized as trustworthy [36], [37]. Additionally, multiple members of the research team participated in both the data condensation and data visualization stages. Researchers met often to compare, discuss, and combine their drafts of data condensation documents for each participant [37] enhancing trustworthiness by leveraging a constant comparative method of data analysis [38].

The findings of this study have limitations related to transferability. One limitation is the admission to major process that occurs at the end of the first year at the institutions where data were collected for this study. This provided a unique context for studying students' decisions related to applying to and choosing an engineering major. Another limitation is the unknown impact that COVID-19 may have had on participants' experiences and therefore decisions made during a time of stress and disruption. These impacts may not have been fully recognized during the interviews even though participants were explicitly asked about their perceived impact of COVID-19 on their lives.

V. Findings

The findings, presented by participant as individual units of analysis, answer the research question for each individual participant of how smartness identity and engineering identity related to decisions of participation in engineering. Additionally, factors that influenced these women's participation decisions that were not solely their own identities as smart or as engineers are also included in these findings, as analysis revealed these factors external to identity to be influential in participation decisions. The results are illustrated through images that map the relationship between engineering and smartness identities (left-most column), and external influences (right-most column) to each participant's decision regarding participation in engineering (center column) throughout a portion of their degree progression (top to bottom of the image).

A. Joining Engineering: Anna

Anna, who joined engineering after spending time in a Finance program through the College of Business, strongly identified as a smart person, but did not strongly identify as an engineer, in all three interviews. This is illustrated in Fig. 2.

According to Anna, being smart was an important part of her identity. Her belief in her own smartness motivated her to join engineering and continue to be a high-academic achiever,

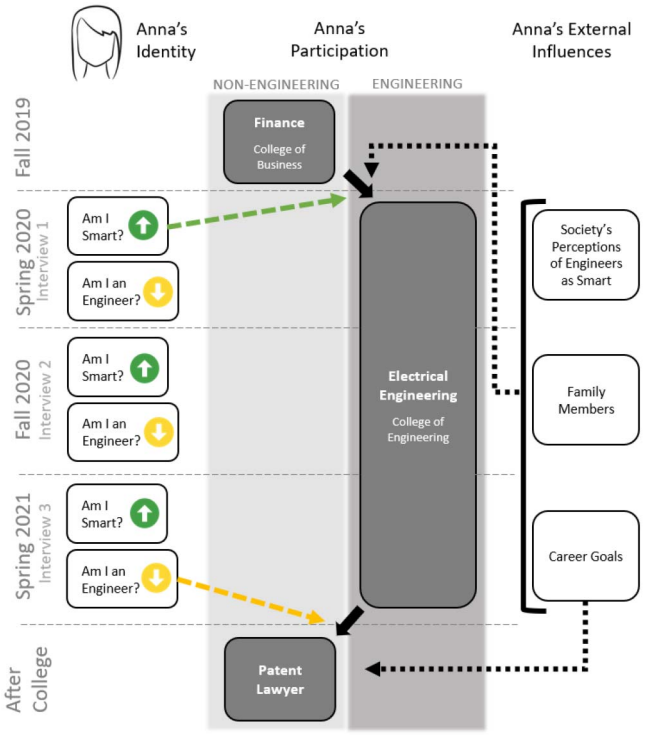

Fig. 2. Anna's strength of smartness and engineering identities as they relate to engineering participation.

as her identity as smart was based on her hard work and motivation. The more she practiced and prioritized academics, the more she felt she could achieve.

"I consider myself to be smart··· I guess I'd say I'm usually pretty motivated. Like I said before, a big part of engineering is you have to be willing to put in the time to do homework and stuff. I'm definitely very willing. I think that's like, academics are the one thing I prioritize··· I guess I would say it's a big part of my identity because I try to be smart and I try to do things that will make me smart."

Anna's smartness identity was strong and salient in her decision to join engineering, after learning that generally, others on campus did not perceive finance majors to be as smart as engineering majors. Anna felt that the academic environment and societal perceptions of being an engineering major would give her the competitive edge she needed to achieve her goals of becoming a patent lawyer.

"I just chose engineering as a means to my end goal which is being a patent lawyer."

Conversely, Anna did not describe being an engineer as a strong part of her identity (majoring in engineering was a means to an end for her goal of becoming a patent lawyer). Anna's younger brother was majoring in computer science engineering, and Anna joined engineering to prove that she was as smart as her brother. When talking about her weaker identity as an engineer, Anna expressed that sometimes she questioned her fit in engineering since she was not interested in a career as an engineer.

"This has always been just a means to the end. What I'm really, really excited about is going to law school···

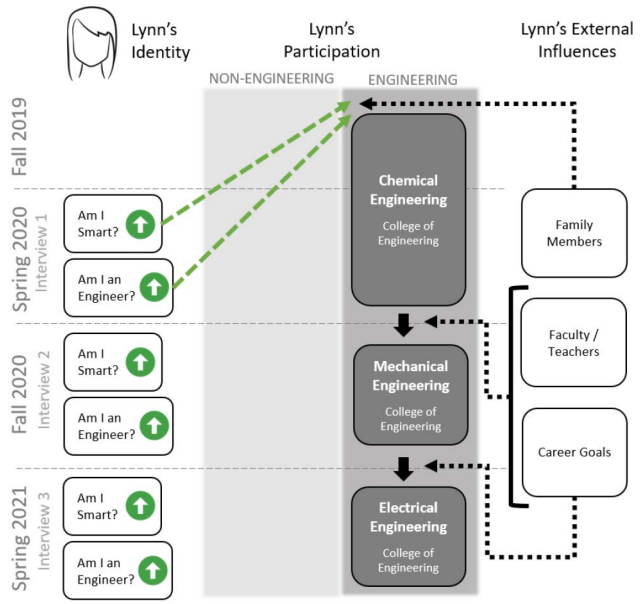

Fig. 3. Lynn's strength of smartness and engineering identities as they relate to engineering participation.

sometimes, that's why I think I'm not as good a fit [for engineering] just because I think that I don't care enough to be an engineer and I don't have the drive that it takes. But I think it's okay to be less interested in things."

In the quote above the emergence of the additional factor of having the goal of attending law school can be seen—this factor being salient in Anna's decision to persist in her engineering major. Her decision to remain in engineering was heavily influenced by her desire to be perceived as smart to better achieve her career goals and attend law school. Anna continued to weakly identify as an engineer through the entirety of this study, as she repeatedly mentioned throughout the study that she has no intention to work in engineering beyond completing her degree. She held on to her goal of becoming a patent lawyer rather than an engineer, so Ana's plan to no longer participate in engineering after college is included in Fig. 2 as well.

B. Switching Within Engineering: Lynn

Lynn, who tried three different engineering majors in her early undergraduate experience, strongly identified as being both smart and an engineer in all three interviews. This is illustrated in Fig. 3.

For Lynn, her engineering identity and smartness identity were both strong and salient in her decision to join engineering. Her main motivation for persisting in engineering was related to what she defined as her innate ability to think like an engineer. She never questioned her identity as an engineer (or as smart) because it was salient for her.

"It's kind of something I've kind of always wanted to do. The field of engineering I've wanted to go into has changed, but not really the fact that I wanted to do engineering."

Lynn only questioned which engineering major would be the best fit as she changed her major several times. Lynn's reasons for joining and switching majors within engineering were often related to factors external to her own smartness and engineering identity, such as family, the influence of her professors, or even evolving career goals.

"I went to mechanical [when] I knew I didn't want to do chemical and mechanical was the only [other major] that I actually knew··· [Then] there was one person that was a professor of electrical engineering and when she was talking about some of the things she had done with her degree, that I could see me being able to do what I want to do with that. So that's when I decided that's the way I wanted to go."

Being an engineer was a salient part of Lynn's identity. Lynn talked about how she had ways of thinking like an engineer. She never questioned her identity as an engineer. She only questioned which engineering major would be the best fit as she changed her major several times. For Lynn, being smart was also a salient aspect of identity. She believed that she was smart in ways that made her a good engineer, and both her identity as smart and as an engineer were closely linked.

"And that's something I've thought about a lot: do I really feel smart because I'm in engineering or do I feel smart because people are telling me I'm smart because I'm in engineering?"

Factors external to her strong smartness and engineering identities motivated her decisions when switching engineering majors. Prior to enrolling in an undergraduate engineering program, Lynn was exposed to engineering disciplines via her mother's work as a civil engineer, her sister's work as a chemical engineer, and her father's work in manufacturing. This exposure to engineering through family members piqued Lynn's initial interest in engineering and heavily informed her decision to initially join engineering. Her decision to ultimately choose electrical engineering as her major was driven by her development of new career goals, based on faculty influences, and aligning her engineering major with engineering interests related to those goals.

C. Leaving Engineering: Emma

Emma started her undergraduate experience in engineering but ultimately decided to leave engineering after one year in the program, despite having a strong smartness and engineering identity in all three interviews as shown in Fig. 4.

Emma's smartness identity was strong and was also salient in her choosing to join engineering. She had been a high-achieving student in high school.

"I was very [much] like [a] perfectionist up until my senior year. And like if I got like, I never got a B, I never like got anything less than a 95."

While Emma spoke about how grades had become less important to her in college, it was clear that being high achieving and being smart was still important to her identity. Emma defined smartness as being able to apply things that you have learned to solve problems and being smart in this way was important to her.

Emma's engineering identity was also salient in her decision to join engineering. She defined the most important aspect of engineering as problem solving and believed herself to be a

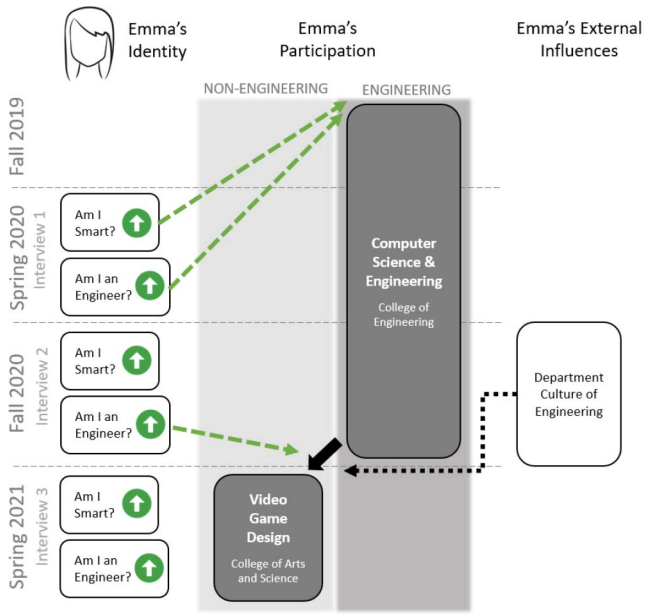

Fig. 4. Emma's strength of smartness and engineering identities as they relate to engineering participation.

good problem solver. Emma also viewed being creative and being empathetic as important aspects of engineering, and she cared deeply about making people's lives better through her engineering design work.

"I do think of engineering as a really broad term. I don't think you have to have any training to be an engineer. I don't think you have to go to college to be an engineer. If you can think about applying the resources you have to a problem that you're currently facing, I think that's what makes you an engineer."

Emma's engineering identity was based on herself being an empathic and creative problem-solver. As Emma progressed through her first year, she felt that the computer science and engineering major focused too much on technical skills, dampened students' creativity, and did not value empathy. Thus, Emma designed her own major within the College of Arts and Sciences for video game design and left engineering.

"I used to be a computer science and engineering major. I liked it when I was taking it. I've always been a computer person. And it started really getting to me when there was really technical stuff that had a huge impact on people, like software design that was incredibly racist. And people [in my program] just didn't seem to care about that. And that really bugged me. And so I realized I had to make the change. I'm now doing a personalized study plan in video game design. I'm focusing a lot on disability in video game design."

Emma's strong smartness identity and engineering identity were salient in her initial decision to join engineering. This related to her ambitions as a high-achieving student and passion for engineering to make the world a better place. However, she did not feel like the culture of the computer science engineering program was fostering what she felt made her smart and a good engineer (empathy, creativity, design, and problem solving). Emma's strong engineering identity was salient in her decision to leave engineering, as her engineering identity did not align with the culture of engineering more broadly that she perceived within the computer science engineering program.

D. Interpretation of Findings

To answer the research questions … *How do engineering identity and smartness identity relate to women's decisions regarding pathways into and through engineering?* And *How are engineering identity and smartness identity related in women's decisions regarding pathways into and through engineering?* … the following synthesis is offered.

Smartness identity was strong for all three women and salient for all three women in their initial decision to join engineering. While participants' definitions of smart and beliefs about determining smartness varied slightly (e.g., family or peer influence or comparison, academic metrics, problem-solving, creativity, or critical thinking ability), each woman consistently and strongly identified as smart throughout all three interviews. Even though smartness identity was overwhelmingly salient when these women decided to join engineering, it was not described as nearly as important or influential when participants were making decisions related to switching majors within engineering or leaving engineering. Therefore, this in-depth qualitative study reveals that a strong identity as smart was important for participants when making the initial decision to join engineering as a field of study, but a strong identity as smart was far less influential comparatively once participants were in an engineering field of study and is making decisions related to continued participation in engineering.

Engineering identity was salient for two of the three women in their initial decision to join engineering. Anna did not strongly identify as an engineer but joined engineering nonetheless. Like smartness identity, whether or not each woman strongly identified as an engineer was consistent across all three interviews. A strong engineering identity was salient in Emma's decision to leave engineering, but not in the way one might expect (e.g., leaving engineering could be related to a lack of engineering identity), as she left engineering because her strong and consistent engineering identity did not align with the culture of engineering as she experienced it. On the other hand, Anna's weaker engineering identity does align with the expectation that engineering identity is correlated with participation in engineering as she described her plan to pursue law rather than engineering as a profession. Therefore, this research also provides evidence that the strength of someone's engineering identity does not necessarily map cleanly onto decisions about participating in engineering. More specifically, the findings indicate that the possession of a strong engineering identity is not necessarily needed to join/persist in engineering, and conversely, a strong engineering identity may not serve as a good enough reason for someone to stay in engineering.

Data analysis led to an additional emergent finding beyond the research question, which was that these women's participation decisions were also informed by influences and considerations external to these women's engineering or

smartness identities, which are referred to in this manuscript as external factors. To be clear, both engineering identity and smartness identity were applied as lenses to explore these women's decisions related to engineering participation, but what emerged was that these external factors interacted with their descriptions of their smartness and engineering identities when it came to making engineering participation decisions. It is possible that the external factors are directly influenced by, or directly influence, other aspects of the participants' identities (not related to being smart or being an engineer) given the complex nature of college students' identity development and maintenance [39], but they are labeled external in this manuscript given their lack of direct relation to these women's smartness and engineering identities. The role of these external factors in the participants' decisions related to engineering participation and how the external factors may indirectly influence the strength of someone's engineering identity or smartness identity is explored and discussed further in the next section.

VI. Discussion

While research in engineering education has pointed to the importance of the development of an engineering identity in attracting and retaining students in undergraduate engineering programs [10], [11], the work in this manuscript presents an alternative perspective: one in which a strong engineering identity is not a clear direct influence in students' decisions to join or leave engineering. Anna joins engineering despite not having a strong engineering identity, and Emma leaves engineering despite maintaining a strong engineering identity. Similar to the findings reported in this manuscript, a quantitative study of engineering students found that the strength of all components of engineering identity is not the most significant predictor of persistence [12]. It should be noted that both the research in this manuscript as well as that of Patrick et al. [12] was conducted at single institutions and across a limited sample of engineering students and majors, so the findings are in no way generalizable to the general population of engineering students and broader engineering identity trends. However, both studies' findings highlight the complexity of engineering identities, and the influence that various components of engineering identity have on student decision making. This research, specifically, focuses on the complex ways in which engineering and smartness identities interact with external factors to influence women's decisions related to joining and continuing participation in engineering.

The existence of external factors beyond the participants' engineering and smartness identities (e.g., family, peers, instructors, engineering culture, career goals, etc.) as salient in the participants' academic decision-making builds on and confirms previous scholarly findings related to engineering participation. For example, the influence of family when it comes to students choosing to participate in engineering can be found in literature [20], as can the influence of instructors [40] as well as a person's career goals and aspirations [41]. It has also been well documented that various elements of engineering culture have made the climate less inviting for women [42] and minoritized populations [43]. The existence of these factors and their effect on engineering participation decisions are not new, and this research makes a contribution to literature in this space by showing how these external influences are described as working in tandem with women's identities as they make decisions about how to participate (or not) in engineering.

Keeping with the identity-based theoretical foundations of this research, *identity congruence (or incongruence)* [44] is proposed as a useful lens through which educators and researchers can begin to understand the complex interactions between a person's identity, their experiences, and external factors, and how those interactions may inform someone's decisions related to participation in engineering.

Identity congruence is described as "an experience when an individual's displayed social identities, such as ethnicity, maturity, gender, and occupational status, are consistent with the identities made available by a group or community" [44, p. 49]. Identity incongruence, conversely, is when a person's identity is not consistent with the group or community they are functioning within. In a learning environment, identity incongruence can lead to negative consequences for the learners, such as compromised self-esteem or being confined to the margins of the learning community [44]. Identity incongruence, or a misalignment between a person's identity and the identity or culture of the group or community they are in, can be uncomfortable, similar to cognitive dissonance [45]. When someone experiences cognitive dissonance, they are confronted with two conflicting views or beliefs on a topic, and the natural human response is to overcome that dissonance by finding a way to reduce the difference between those two viewpoints [45]. The authors posit that just as people naturally work to overcome and resolve cognitive dissonance to reduce discomfort, they are also naturally driven to make decisions that resolve identity incongruence to reduce discomfort or limit any negative consequences of that incongruence.

Next, the use of identity congruence as a theoretical lens for the broader motivation for the research participants' decisions about participation in engineering is presented. In the cases of these three women, the decisions they each made regarding engineering participation could be interpreted as a possible means to achieve identity congruence amidst a complex interaction of the strengths of their engineering and smartness identities, external influences, and the group or community they function within.

A. Joining Engineering: Anna

Anna joined engineering and persisted despite not expressing a strong engineering identity within the timeframe of this research. The authors posit that Anna sought identity congruence related to her strong smartness identity and therefore joined engineering to achieve that congruence, as pictured in Fig. 5.

Anna strongly identified as smart, and Anna also said in her interview that because she was a finance major in the College of Business that people perceived her to be less smart

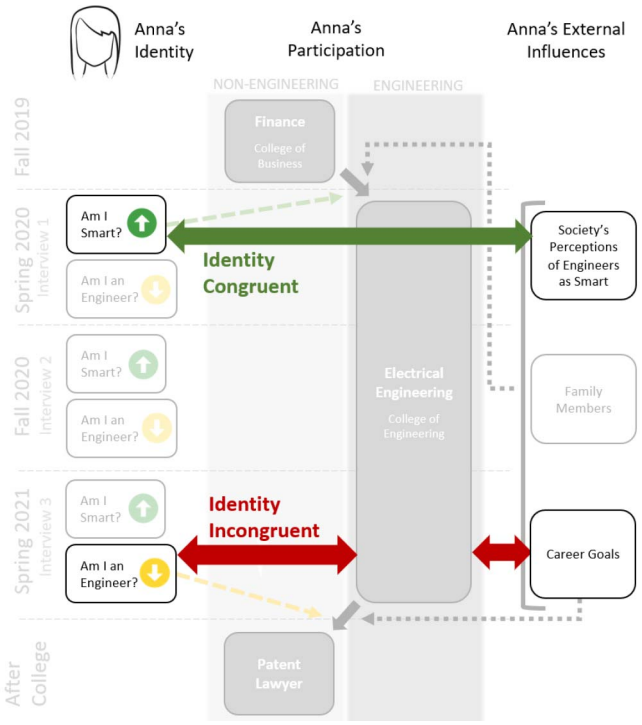

Fig. 5. Anna's instances of identity congruence and incongruence.

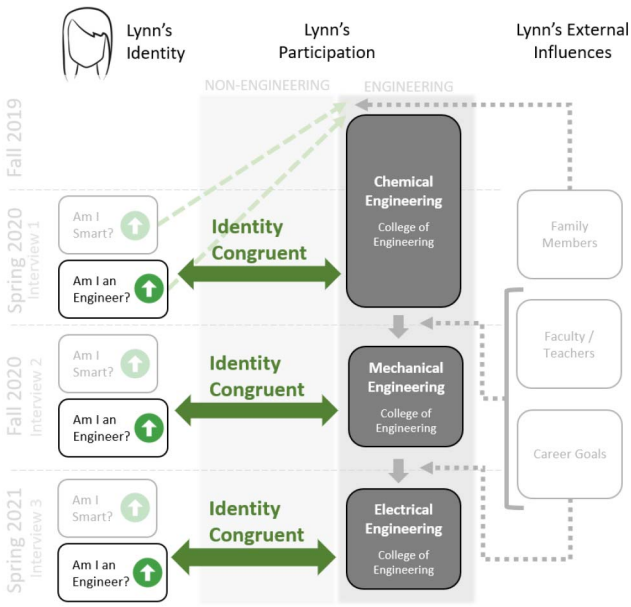

Fig. 6. Lynn's instances of identity congruence.

compared to those in engineering. She shared that her brother was an engineering major, and she believed that she was as smart as he was, so she joined engineering to prove how smart she was. Anna at no point joined engineering to do engineering work. Anna's weak engineering identity manifests through her repeated descriptions of having no interest in ever pursuing a career or job in the field of engineering. Anna joined engineering and persisted within engineering while maintaining a weak engineering identity solely to be viewed as smart, as she knew the perception of being smart would be important in advancing in her career goals of going to law school and becoming a patent lawyer. Although this might seem like a round-about way to achieve her career goals, Anna's perceptions are not incorrect. Engineering students are often recognized as smart for participating and persisting in undergraduate engineering programs as it is a field that is perceived to be more difficult than others, particularly with the perceived emphasis on math and science [27], [28], [46], [47]. Through all three interviews, Anna maintained that she will not do engineering work after graduating with an engineering degree, but instead will pursue being a patent lawyer.

Using identity congruence theory as a lens to interpret and explore Anna's engineering participation decisions the authors posit that her stronger identity as smart was congruent with the general perception of those who study engineering, so she chose to join engineering despite her much weaker identity as an engineer as a way to community her identity as smart to others. Anna's career goals were not congruent with electrical engineering and appear to heavily influence her description of her weak engineering identity, and that is why she has no intention of working as an engineer when she graduates but instead plans to attend law school and become a patent lawyer.

B. Switching Within Engineering: Lynn

Lynn expressed both a strong engineering and smartness identity that were closely related, meaning her definition of what it meant to be an engineer and what it meant to be smart were nearly one in the same. The authors posit that Lynn remained in engineering despite many switches of major to maintain congruence between her own strong and salient identities as smart and as an engineer and the community she was choosing to function within, as shown in Fig. 6.

Lynn was confident in her identity as an engineer, this confidence deriving from the fact that studying engineering continued being a goal of hers and she believed she had the skills necessary to be successful based on her knowledge of her family members' engineering skills and experiences. However, the data shows us that Lynn seemed to struggle to find her place in engineering, as she tried three different engineering majors in a row, the first and second informed by familiarity through family members, and the third influenced by a faculty member and her own career goals.

Using identity congruence theory as a lens to interpret and explore Lynn's engineering participation decisions, the authors postulate that her strong identity as an engineer and as smart is what kept all of her "switching" within the engineering field. Lynn continuously identified as smart and as an engineer, and therefore in order to keep her field of study (and therefore the community she is participating in academically) congruent with her strong smart and engineer identities she only switched to majors that were included in the broader field of engineering despite many switches to find a major that she enjoyed and helped her work toward her career goals.

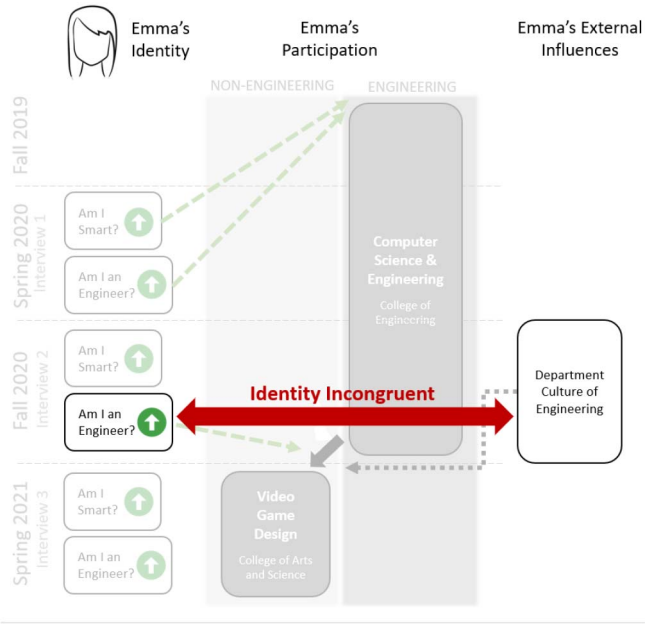

Fig. 7. Emma's instances of identity incongruence.

C. Leaving Engineering: Emma

Emma expressed a strong engineering identity but ultimately decided to leave engineering because she did not feel that her values and her own engineering identity aligned with those of the engineering program she was enrolled in. In other words, she did not feel that her understanding of what engineering is (or should be) aligned with what was being taught in the program and how. The authors posit that Emma left engineering because her engineering identity was not congruent with the engineering community she was participating in, as pictured in Fig. 7.

Emma's identity as an engineer persist and maintains strength throughout all three interviews, and Emma has a nontraditional definition of engineering, as described in the results section. Emma personally values creativity and empathy in her approach to engineering problem solving, but she feels as though these values are not shared by other engineers in the academic community she was functioning within (the Department of Computer Science and Engineering). Emma's perceptions of her engineering learning environment align with research that has found technical knowledge to be far more valued in engineering than creativity, empathy, social welfare considerations, or other skills viewed as inferior to technical knowledge [48], [49].

Using identity congruence theory as a lens to interpret and explore Emma's engineering participation decisions, the authors postulate that Emma realizes that her own engineering identity and the values and ideals she associated with that identity is incongruent with the ideals and values of the engineering community she was functioning within while studying engineering and therefore left engineering and created an individualized plan of study in another college to reduce the incongruence between that of her own strong engineering identity and her academic community she was functioning within.

VII. Conclusion

This study contributes to existing research by examining how women's engineering identity and smartness identity relate to their decisions to participate in engineering majors. A strong identity as smart was salient in all three participants' descriptions of their initial decision to major in engineering and a strong identity as an engineer was salient in two participants' initial decision to major in engineering. For all three participants, the strength of their engineering identity and smartness identity remained stable as they made their decisions to join, persist, switch majors within, or leave engineering. They also described their decisions as influenced by factors external to their smartness and engineering identities, such as family members, who were engineers, influential professors, and the culture of an engineering program. Ultimately, this research highlights the complexity surrounding women's decisions related to engineering participation. These complexities are discussed through the lens of identity congruence, using this framework to connect the nuanced interaction between women's identity and external factors in engineering participation decisions. This research also makes a contribution to the study of identity congruence, as this research indicates that while identity (in)congruence is something that is often experienced and studied within a present community, it can also be something that is used for consideration and planning pathways in relation to future goals.

Based on the findings of this study, it is recommended that future studies address smartness identity as a salient factor in the decision to major in engineering. Particularly addressing how the inequitable cultural practice of smartness contributes to the under-representation of women in engineering fields, such as electrical engineering, computer engineering, and computer science. Future studies should also address how external factors, particularly the culture of engineering programs, that are salient in women's decision-making relate to their engineering identity and smartness identity congruence. The data from this study suggest there is more complexity in this decision-making process related to the many identities and factors that women navigate when making decisions to join or leave engineering.

Finally, both educators and researchers alike should strive to gain knowledge and understanding of the many complex ways in which students' various identities function alongside instructors' own engineering identities, function within engineering classrooms, and relate to broader engineering communities. While identity congruence theory is used to further interpret these research findings that serve as counter-stories to the findings of others who note the relationship between stronger engineering identities and increased and prolonged academic participation in engineering [10], [11], the message that holds true is that students' identities do influence their decisions to participate in engineering and persist in the field. It remains important that research continues related to the complexities of engineering students' identities in relation to engineering participation to appropriately grow the field, specifically with regards to those under-represented

TABLE II
SAMPLE INTERVIEW PROTOCOL QUESTIONS FROM INTERVIEWS 1–3

First Interview
What does it mean to be an engineer?
Based on that definition, do you consider yourself to be an engineer? Why or why not?
When did you become or when will you be an engineer?
What skills do you have or don't have that relate to engineering?
Have you ever questioned your fit as an engineering student? When and why?
Generally speaking, what does it mean to be smart?
Based on that definition, do you consider yourself to be smart? Why or why not?
What skills/characteristics do you have or don't have that relate to being smart? Is being smart a big part of who you are?
Have you ever questioned how smart you are? When and why?
Second Interview
Give me a brief overview of the courses you took and your grades from last year.
How do you feel about grades from last year?
How did these grades factor into your decisions for your academic plans this semester? How do these grades relate to your pursuit of earning an engineering degree / becoming an engineer?
Tell me about the courses you are currently enrolled in.
Why did you choose these courses?
Did your previous grades or GPA influence your choice in courses this semester?
[If no longer enrolled in engineering] Tell me about the experiences that led to your decision to change your major from engineering to [new major].
Third Interview
In what ways did you understand yourself to be smarter than others before college?
How did that matter in your life?
In your academic decisions?
In what ways do you understand yourself to be smarter than other engineering students?
How is that mattering in your life right now?
In your academic decisions?
In what ways do you understand yourself to be less smart than other engineering students right now?
How is that mattering in your life right now?
In your academic decisions?

in engineering. Without this growth, the field of engineering will struggle to keep pace with the complex problems the world faces.

APPENDIX

See Table II.

ACKNOWLEDGMENT

Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the NSF. Acknowledgment are also given to the participants of this project, without whom the research would not have been possible, as well as the team of researchers who worked diligently to conduct high-quality complex and in-depth analysis of the data.

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