Retrospective Insights in Choosing a Career in Engineering

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Abstract

Women have historically been underrepresented in science, technology, engineering, and mathematics (STEM) fields [1]. The gender gap in participation in engineering remains especially large, and the cause of this gap is the question of many researchers [2],[3],[4]. Research teams have found that perceptions of the field, specifically that it is nonempathetic and noncommunal goal-oriented, is a deterrent for women, who additionally receive less direct encouragement to join the field [5], [6]. Several research teams have probed motivation for selecting engineering in college students [7], [8],[9]; here, we considered motivation from the perspective of those who are currently working as engineering educators. Specifically, we held focus groups with 10 engineering faculty, seeking to answer the research questions "What motivates individuals to become engineers?" and "How can the knowledge of these motivators be used to broaden participation in this field?" Focus group responses were analyzed using thematic analysis with Situated Expectancy-Value Theory (SEVT) as a framework [10]. Components of SEVT, expectancies for success or subjective task values, were found in all participant responses. Responses from many participants included the motivations of interest in STEM and curiosity towards building and creating. Females in the field demonstrated a greater interest in the profession due to the communal goals of engineering as opposed to the agentic goals expressed largely by the male participants. Aligned with SEVT, both men and women participants were motivated to pursue tasks they enjoyed and that were related to areas of expected success. Two contributions to expectancies of success emerged from participant responses: past achievements and extrinsic motivation. Male and female participants mentioned these in their responses, but females more often discussed extrinsic motivators, direct encouragement to pursue engineering from a trusted source. Additionally, patterns in contributions to intrinsic motivations emerged from participant responses. Cultural context was found to be an unexpected but prevalent intrinsic motivator mentioned in both male and female participants. While cultural context cannot easily be addressed to broaden participation, recognizing and encouraging engineering-related interests and achievements in women could help develop engineering identities in women and increase participation. This paper contributes examples of the need for explicit and extrinsic motivators for women to become engineers due to the historical lack of societal pushes towards engineering that often men receive. Additionally, the narratives provided in this work highlight the misperceptions of the field and point to the relevancy of interventions to address the disconnect in agentic perceptions of the field and actual communal nature of the profession.

I. Introduction

Although female participation has increased significantly in some STEM fields over the last few decades, it has increased minimally in engineering. Women now make up 55% of biological sciences but only 9% and 10% in electrical engineering and mechanical engineering disciplines, for example [11]. A lack of representation causes a lack of perspectives in the field. The more perspectives taken when considering a solution broadens its validity and applicability. As engineers are called to consider paramount the safety and welfare of the public by the National Society of Professional Engineers Code of Ethics, it is necessary to consider a range of perspectives to produce solutions representative of all individuals [12]. Additionally, females have been found to generally display more empathy, the capacity to understand the perspectives of others, than males [5]. Thus, increasing female participation in engineering could lead to an increase in empathy demonstrated in engineering solutions. Empathy allows engineers to better understand the needs of society, so more empathy could allow engineers to better meet these needs. Efforts should be taken to reduce the gap in male and female participation in engineering to capitalize on this "untapped human capital" [13]. To broaden participation, it is first necessary to understand what motivates individuals towards a career in engineering.

Many researchers seek to understand what motivates an individual to choose a college major and career to better understand this lack of representation [14], [15]. These efforts have resulted in several theories of career motivation. The Situated Expectancy Value Theory (SEVT) has been considered successful in explaining motivators of participation and performance. Developed by Eccles and Wigfield, the theory posits that motivation and performance are most directly influenced by an individual's expectancies for success (ES) and subjective task value (STV) [10]. ESs and STVs are ultimately established through individuals' beliefs of themselves, their abilities, and goals. An ES is an individual's belief they will be successful in a task, and an STV is how much value an individual finds in completing a task successfully. An STV can be defined by how much a person enjoys the task (intrinsic value), how useful a person thinks it will be for present and future goals and tasks (utility value), how important it is for this person to accomplish this according to their identity (attainment value), and the consideration of drawbacks of performing the task (cost). The cost of a task can be further broken down into three types of costs: the perceived amount of effort necessary to complete the task (effort cost), the loss of the time and ability to complete other valued tasks (opportunity cost), and the costs of negative emotions attributed with completing the task such as anxiety and the threat of failure (emotional cost) [10].

Eccles and Wigfield established the SEVT to understand motivations to participate and perform in various tasks to better understand why less females choose to enter STEM fields, but other theories that study motivation and gender more broadly were also relevant for this research such as Social Role Theory (SRT) and Social Cognitive Career Theory (SCCT). These theories focus on the role gender plays in everyday experiences and social interactions as well as in an individual's choice in career. Social Role Theory argues that gender stereotypes and gender role beliefs influence how people behave and that these beliefs are formed through observations of groups [16]. Social Cognitive Career Theory argues that individuals' career choices are also influenced by gender roles [8]. A research team tested individuals' accuracy regarding known stereotypes of groups [17]. The researchers found participants were able to link stereotypes with occupations, in agreement with the SRT [17]. Stereotypes exist concerning the role of women in the workplace according to observations of groups in the workplace, and women are still affected by these stereotypes [17]. Others use SCCT to explore the role of gender stereotypes as a deterrent for women from engineering and have found that stereotypes play a significant role [18]. With the SCCT as a framework, the effect of stereotypes on confidence and motivation to become an engineer were measured with efficacy and stereotype scales in college engineering students. The study demonstrated that stereotypes of the nature of the profession and of the individuals in the profession affect women's motivation to become engineers [18].

In addition to being a "stereotypically male" profession, engineering is perceived as an agentic profession, focused on self and task-driven goals. It has been found that women tend to choose professions that allow them to participate in their communal goals [9]. Regardless of the actual goals of the profession the perception is that engineering is agentic [17]. This difference between perceived goals of the profession and communal goals can lead to women lacking the personal identities that motivate men to become engineers [19]. It has also been found that women often lack the cultural influences that shape intrinsic motivators towards a career in STEM, contributing further to the lack of science or math identities [10]. The SCCT explains career interests, choices, and performance through the effect of personal traits, such as self-efficacy and outcome expectations, on interests and the effects of those interests on goals and actions [20]. The theory validates the influences of social interactions on career choice, and other research has been conducted that explores the specific cultural effects on these potential career motivators, examining the similarities and differences between men and women. A theme found in others' research on cultural motivators is the lack of recognition for females in science and math, causing a lack of STEM identity formations [21]. It was found that while recognition does not directly affect performance, it has the largest direct effect on physics and math identities and contributes to the lack of representation of women in engineering [21]. While much research has supported these theories, greater insight is needed through narratives to confirm sources of motivation towards a career in engineering, specifically from those who are currently participating in the discipline.

Using the theories discussed above as a guide, our study probes the many possible contributions to motivation from the unique perspective of engineering educators, who have already joined and persist in the field. These retrospective accounts allow for the descriptive corroboration of motivations discussed in other works, while providing insight on the values and experiences of engineering educators. Our participants, current engineering educators, reflected on impactful contributions to their motivations to pursue engineering. Existing research considers high school and college students motivations to become engineers [7], [9], [22], but few studies consider the motivations of those who are currently engineering faculty. Here we asked engineering educators "What made you want to be an engineer?" and analyzed their responses through thematic analysis. We seek to answer two research questions from participant responses: "What motivates an individual to become an engineer?" and "How can this understanding be used to broaden participation in engineering?" By asking educators to reflect, we are able to identify components of motivation that ultimately lead to a career in the field, rather than simply an interest in the field. We considered similarities and differences in female and male responses to determine if and how gender affects an individual's desire to be an engineer. Based on the themes that emerged from our data, we offer actions that can be taken to broaden participation.

II. Methods

A. Data Collection

Our data was collected from 10 engineering educators. As this is human subject research, it has been conducted in accordance with our institutional review board (IRB). Demographics of these ten participants are included in Table 1. This study is reflective in nature, unique from others' work that has considered those pursuing formal training [8], [23], as it asks those currently in the profession to describe their motivations to become an engineer. These individuals volunteered and consented to participate in focus groups with other engineering educators. Participants were recruited via cold emails, as well as sharing information about the study at engineering conferences and social media. An email was sent to the engineering department of 89 state schools, up to two schools per state, and 13 Historically Black Colleges and Universities (HBCUs) throughout the United States. Our full focus group protocol consisted of six questions; the responses to the first question, "What made you want to be an engineer?" is the subject of this paper. The conversations were held in focus group interviews ranging from one to three participants over Zoom. Zoom automatically transcribed these focus groups, and a member of the research team read each transcript to check for accuracy. The transcripts were used as our data for this research and were analyzed in the qualitative analysis software MAQDA, through the thematic analysis approach described in the following section.

Table 1: Demographics of participants provided in survey

Discipline	Biological	Chemical	Civil	Dean	Electrical	Industrial	Mechanical	Total
Number of Participants	1	1	1	1	1	1	4	10
Years of Experience	0-5 years	6-15 years	25+ years					Total
Number of Participants	1	5	4					10
Gender	Male	Female						Total
Number of Participants	5	5						10
Race/Ethnicity	White/ Caucasian	Black/African American						Total
Number of Participants	8	2						10

B. Thematic Analysis

We followed Braun and Clarke's approach for thematic analysis for this study [24], [25]. This approach has six steps: familiarizing yourself with your data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report. Additionally, we considered reliability typologies outlined by Walthers and coworkers, such as checking of transcripts and documented focus group protocols [26].

1. Familiarizing yourself with your data

The data was collected in Zoom meetings from focus groups, and the transcripts, after being checked for accuracy, were read through multiple times to form ideas about patterns in responses. Potential patterns were noted and discussed by members of the team as focus groups were conducted and again as the transcripts were read through after all interviews had been conducted. We sought to find themes in motivation, gendered and not gendered, so participant responses, while deidentified, remained connected to the participant's gender. Frequent motivators mentioned by participants and in other literature were tallied by hand for male and female responses. Some motivators seemed universally experienced, and some seemed to be experienced more frequently by one gender. This was noted as initial codes were generated.

2. Generating initial codes

Conversations with the participants were held in five focus group interviews. The first author was assigned the role of considering relevant theories for a framework, and after extensive search through literature, she found SEVT provided the most holistic explanation for motivations. Although the SEVT provided a sound theoretical framework, it was found to lack some aspects of motivation that was seen in initial reading of participant responses and other literature. Components of these were included as subcodes. The addition of subcodes is not a modification or correction of the theory but rather an extension. The theory was designed to understand the different effects on motivation to better understand the cause for the lack of female participation in STEM fields. The intention of this paper is to explore the different motivations for engineering specifically, so it was considered necessary to include subcodes that more specifically addressed these motivations.

Initial generation of codes was both inductive and deductive to include both components of motivation outlined by the theory and those that were noticed to occur in the focus groups and other literature. The SEVT poses that motivation and performance is influenced primarily by two things, expectancies for success (ES) and assigned subjective task value (STV). As suggested by the framework, ES and STV were included as the two primary codes. The four components of STV in the theory, attainment value, intrinsic value, utility, and cost, were included as subcodes for STV. The three components of cost as outlined in the theory, effort cost, opportunity cost, and psychological cost, were included as subcodes of the subcode cost. The theory does not include components of utility, intrinsic value, or attainment value, so subcodes were added to original codes to further categorize based on what was seen in responses. Financial motivation was mentioned by multiple participants, so it was added as a subcode of the subcode utility. There were no other apparent components of utility, so this was the only subcode initially. Three components of intrinsic value were noticed after we familiarized ourselves with the data: interest in STEM, wanting to build/create, and being curious. These were included as subcodes for intrinsic value. As seen in literature and noticed while conducting focus groups, women were more interested in the communal aspects of engineering, so communal goals was included as a subcode of attainment value to further assess this pattern. The theory accounts for many internal motivators but few external motivators, so a third main code External Values was included. Two external values were proposed as subcodes: projects/hands on experiences and recognition from family, friends, and teachers. The first author completed an initial coding with these codes and subcodes and discussed with the team.

After discussion, some slight modifications were made to the codes. Rather than including External Values, which did not have any coded statements, the research team agreed that Extrinsic Validation was a more accurate description of what participants were expressing. This was included as a subcode for ES. Projects/hands on experience and recognition from family, friends, and teachers, were then included as subcodes for the Extrinsic Validation code. A subcode for Achievement was also added to the ES code. The need for a Cultural Context code for intrinsic motivation was also noticed. There were several instances when participants mentioned the effect the context in which they grew up had on their motivation to become an engineer without mentioning an explicit motivation. For example, many participants grew up in families with a member of the family being an engineer, and that introduced the possibility of becoming an engineer themselves, but the family member did not explicitly suggest or motivate them to do so. Originally, these statements were coded as motivation from a family member, but because it was not explicit, this would not accurately represent the effect of the family member.

3. Reviewing themes and defining themes

While our sample size was limited, patterns and potential themes did emerge that were both consistent with expectations and not yet seen in other works. As we reread the transcripts as a group, we continued to remove codes that were not used as frequently as expected, such as the curiosity code, as we came closer to defining themes. No further utility motivations were observed, so we removed the financial subcode and left only the utility code. We removed the project/hands on experience subcode of the extrinsic validation code, as only one statement related to this subcode. All that remained was the recognition of family/teacher/friend, so this subcode was removed as well, and all statements with this subcode were coded as extrinsic validation. At this point, the agentic goal subcode was added. Often in literature, communal goals are compared to agentic goals. Agentic goals were not originally noticed in the reviewing of the transcripts and codes, but statements containing agentic goals were observed after considering the definition of agentic. We reread the transcripts until no modifications were made and all statements were accurately represented by the coding. This occurred over a three-month period where the authors met biweekly.

After all codes were established, we assessed the frequency of each and the gendered difference in occurrence. We saw that responses were aligned with the SEVT, but the narratives provided allowed further insight on sources of motivation. Responses shed light on what specifically motivated individuals to become an engineer. Examples of these insights are provided and explored as we seek to use findings to suggest means for broadening participation. Our final code structure is displayed in Figure 1.

III. Results and Discussion

A. Expectancies for Success

The belief of how well an individual performs in a task influences motivation to pursue and engage in that task [15]. According to the SEVT, individuals are motivated towards tasks they believe they will succeed in, and we noticed this in many participant responses. The theory does not provide further categorization of ES, but we noticed two elements emerge as contributions to participants' ES for engineering: past achievements and extrinsic validation, as displayed in Figure 1 and described in more detail in the following sections.

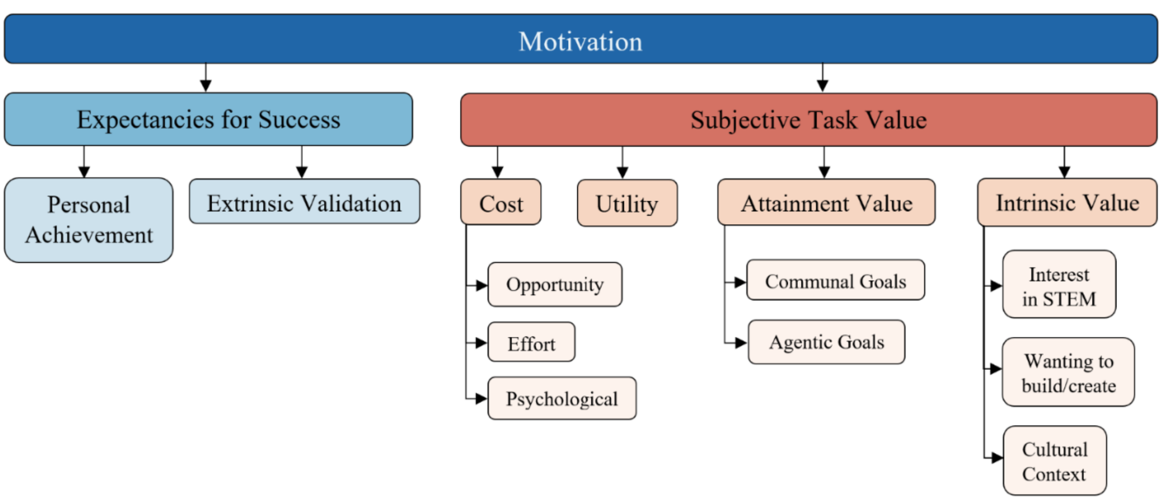


Figure 1: Coding structure including components of SEVT and additional subcodes

1. Personal Achievement

We coded statements as Personal Achievement if a participant mentioned skills and past successes related to engineering in response to being asked why they wanted to become an engineer. As provided in Table 2 along with other statements as examples for each code, participants discussed an interest in college majors and careers that they thought aligned with their skill strengths. A participant stated that she switched majors several times and “By the time I got to my fourth or fifth major, I found one that better suited my skill sets” (EE7). She chose to stay in the engineering major because she had the skills to do so. Others saw engineering as “an interesting path to, to apply my skills in, in math and science” and that they were “able to answer the questions more meaningfully” because of past experiences and achievements (EE3 and EE5). Participants reflected on past achievements and how they contributed to the belief that they would be successful in engineering. Their responses aligned with the SEVT, demonstrating that past achievements shaped their beliefs of future successes, and these expectancies of success in engineering led to an interest in the profession.

Table 2: Examples of statements for each code and subcode

Expectancies of Success	Achievement		"I saw that it was an interesting path to apply my skills in math and science."
	Extrinsic Validation		"It was a boy in the cafeteria who liked math and science like I did, and he said, 'why don't you be an engineer?'"
Subjective Task Value	Cost	Opportunity	No statements
		Effort	"But it was a little bit like labor intensive and I was not physically, not strong enough. Mentally I was very strong, but physically not very strong strong enough. So I didn't like it much, but eventually it shape me choose my career."
		Psychological	No statements
	Utility		"He was telling me to go to material, material science or material engineer because they're making a lot of money because he was working at that raw material company.”
	Attainment Value	Communal Goals	“And so for being able to see engineering for serving humanity… I guess being able to see that engineering can have a positive impact was confirmed that I was in the right place.”
		Agentic Goals	"They told me, well, you know, you're gonna be a medical doctor whether you like it or not. And I said, well, I'm gonna be a doctor, but not a medical one."
	Intrinsic Value	Interest in STEM	"When I was very young, I was fascinated with math, sciences in general."
		Build/create	"The idea of creating something new was what really brought me to engineering, the excitement and the curiosity behind it."
		Cultural Context	"I grew up in the Detroit area and a lot of, lot of folks worked in, in the automobile industry."

2. Extrinsic Validation

Multiple participants mentioned the effect of extrinsic motivators on their ES in engineering. Several examples were provided that demonstrated the influence other individuals had on participants’ ES and motivation to become an engineer. These encounters made participants aware of the possibility of engineering as a career choice and led them to believe they could succeed in it. A participant was influenced by “a boy in the cafeteria who liked math and science like I did” and by her dad when he told her to “be a chemical engineer because they make the most money” (EE9). She was told that because of her skills in math and science, she should consider engineering. Another participant mentioned considering another career, but his “mother had something else to say about that” (EE6). A member of his family encouraged him away from other professions and towards engineering. Extrinsic validation mentioned by participants supports the SEVT by demonstrating that if an individual has come to believe that they have a skill through the validation of others, they are likely to pursue tasks involving that skill.

B. Subjective Task Value

In addition to ES, the SEVT claims STVs have an effect on motivation. Interested in why some individuals value and pursue engineering, we sought to understand the contributions to engineering STVs and compare them to the elements of STVs defined in the theory: cost, utility, attainment value, and intrinsic value. The theory does not provide examples of attainment values and intrinsic values due to the broad nature of the theory, but participant responses identified some related to engineering specifically. We saw each element in responses and further categorized attainment value by relating to communal goals or agentic goals and categorized intrinsic values as interest in STEM, wanting to build/create, and cultural context. Examples of such statements and their corresponding code are also provided in Table 2.

1. Cost

We only saw two examples of cost in participant responses, understandably since we probed what motivated them towards engineering, not away from engineering. Costs are disadvantages associated with a task and can often motivate somebody to not pursue that task. All participants were engineering educators, so none were deterred from the profession, explaining the lack of costs. The costs mentioned were effort costs and explained why the participant was discouraged from another career. This participant spent summers working in a labor-intensive job and decided "Mentally I was very strong but physically not very strong enough." This led him to pursue engineering (EE5). Participants did not mention tasks they could not pursue by pursuing engineering (opportunity costs) or the emotional burden of engineering (psychological costs) when explaining what made them want to become an engineer. Interestingly, two female participants prefaced their response by stating that they originally did not want to be an engineer. One female participant "actually didn't want to be an engineer" and "started out as a chemistry major and kind of fell into engineering after I decided I didn't like chemistry" (EE2). The other "didn't want to be an engineer" or "an educator" (EE7). She originally was "going to be a medical doctor" but decided against that. She considered other majors before engineering and decided she "didn't want to do biology or chemistry" either, "so as a practical solution, I tried out different kinds of engineering" (EE7). While they mentioned not wanting to join the profession, they did not elaborate on what the perceived costs of doing so were. They only mentioned what their original plans were. Only female participants made these statements, indicating that there could be a factor deterring women but not men from the profession. Further exploration is needed to understand what specifically this deterrent is, but these statements allude to a disconnect in the perception of the field and personal identities in women.

2. Utility

A person may value a task according to how useful the task is and the benefits it provides. We saw a total of eight statements made by five participants that related to utility. We coded statements as utility if the participant mentioned how engineering was a practical means of acquiring something they needed. This was always financially related. Participants directly mentioned financial utility by discussing engineering salaries, with statements such as “I ended up going into engineering, and my dad said be a chemical engineer because they make the most money” and “go to material science or material engineer because they’re making a lot of money” (EE9, EE5). They also indirectly discussed financial utility by mentioning it as an opportunity for a job, with statements such as “I would get some training so I would have an occupation” and “I could get a job” (EE9, EE5, EE4). Participants mentioned either being drawn to the field by the salary or choosing engineering instead of other careers because of the anticipated salary. Like SEVT posits, participants were motivated towards tasks that are useful and meet a need.

3. Attainment Value

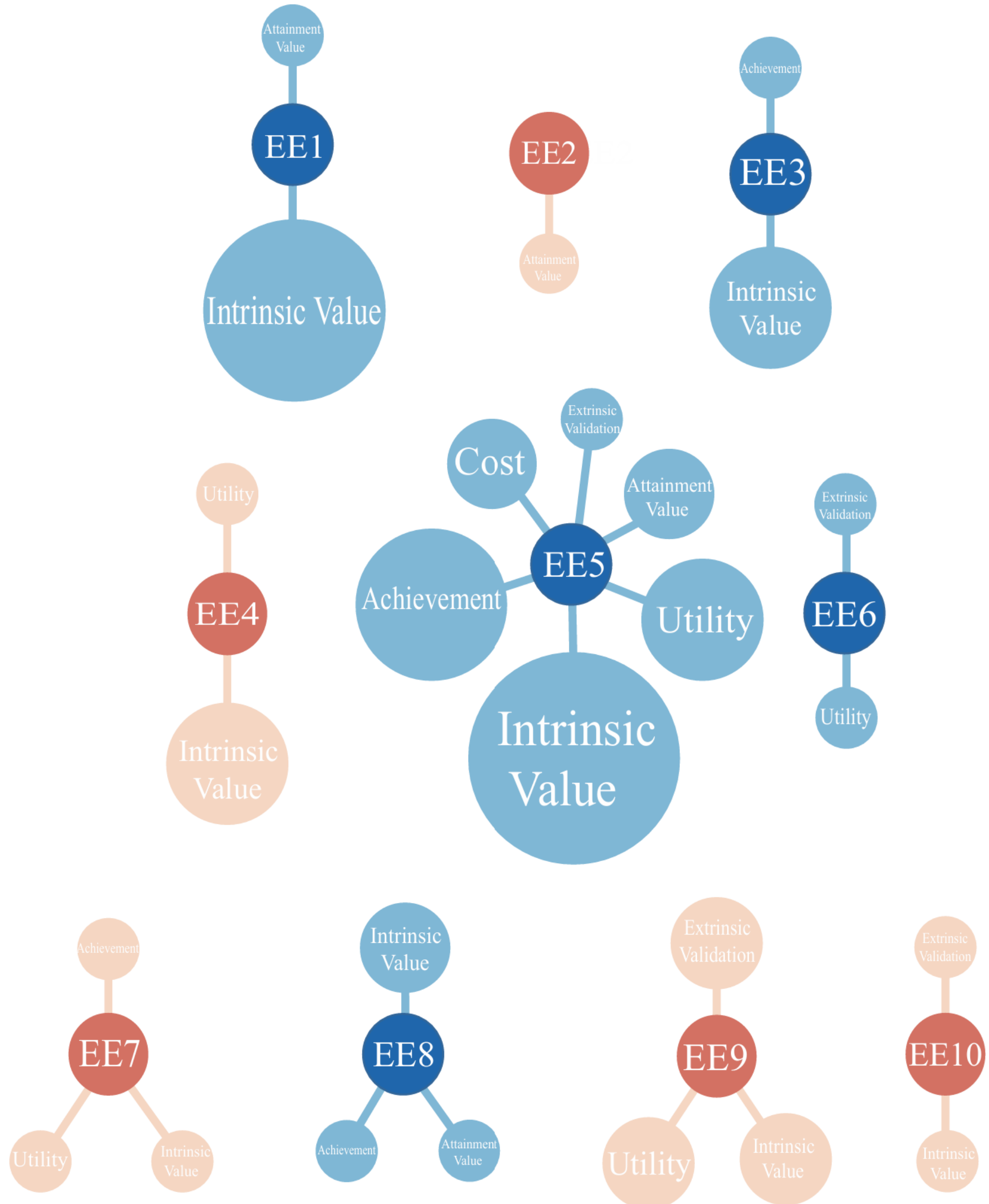
According to the SEVT, individuals are motivated to complete tasks they find important, and that importance can be shaped by personal and social identities [10]. Tasks can be important for people if they associate with the tasks and the way it allows them to pursue an aspect of themselves. A person may identify as a selfless person, a numbers person, a curious person, or countless other identities. It has been suggested that people are motivated to engage in tasks that align with these identities and with what they consider important about themselves. We noticed two categories of attainment values in participant responses: agentic and communal goals. Agentic goals are defined as self-oriented goals, and communal goals as other-oriented [9]. Agentic goals are characterized by ideas of success and can be driven by traits like independence, competitiveness, and ambition [17]. We coded statements as agentic goals if participants mentioned wanting to pursue engineering to achieve a feeling of personal success, and we coded statements as communal goals if participants mentioned wanting to pursue engineering to better their community. For example, it was important to a participant that he became a doctor, and he decided “I’m gonna be a doctor, but not a medical one.” He earned his doctorate in engineering (EE1). His idea of success and his career motivation were shaped by his agentic goals. Another individual mentioned that what drew her to the profession was “a humanitarian project” where she “finally realized that engineering could be used to make a positive impact” (EE2). This participant’s career choice was driven by her communal goals, and engineering satisfied these goals. Individuals described their personal identities of success, how those definitions were influenced by their community, and how these ideas contributed to their motivation to choose engineering as a career, so we considered these agentic statements as attainment values. Some statements demonstrated the importance for individuals to serve society with their profession leading to the choice of engineering, so we considered communal goals to also be attainment values.

4. Intrinsic Value

While the SEVT does not provide further categorization of intrinsic values, it suggests that individuals pursue tasks they enjoy. We noticed three common interests that motivated participants to become engineers: an interest in STEM, wanting to build/create, and cultural context. We coded any statements mentioning an interest in something related to science, technology, engineering, or math as a reason the participant believed they would enjoy engineering as a profession as an interest in STEM such as “when I was very young, I was fascinated with math and science” and “I was really interested in chemistry in high school” (EE1 and EE8). A participant was considering which major she wanted to pursue, and said she knew she “wanted to do something in STEM” and chose engineering (EE10). Participants often thought they would like engineering as a profession because they liked to build and create. We coded statements as Build/Create if they mentioned wanting to design or make something such as “I think just the idea of creating something new was what really brought me to engineering” (EE8). One participant mentioned how he liked to “take things apart and put things together” (EE1). Another discussed how he was “interested in chemistry in high school” and learned about how materials engineers use “chemistry and basically apply it in new ways to create new things,” so he became a materials engineer (EE8). Multiple participants also made statements that demonstrate the effect of culture on their desire to be an engineer. If the location or culture a participant grew up in was mentioned as an indirect influence on their choice of engineering as a profession, the statement was coded as cultural context. One participant, for example, “grew up in the Detroit area and a lot of, lot of folks worked in the automobile industry” (EE3). He was exposed to the profession growing up because of where he lived, so he was influenced to consider this as a possible career choice for himself. His local culture during his youth indirectly influenced his desire to become an engineer. Another participant mentioned that she had “a father who’s an engineer, although he did not encourage me to go into engineering” (EE9). Her father being an engineer indirectly influenced her to consider joining the profession. This was not considered extrinsic validation because he did not validate her skills or develop her expectancies for success as an engineer. A participant who originally thought she “was going to be a medical doctor” changed her major and “tried out different kinds of engineering” (EE7). Her cultural context influenced her change in major because she went “to Georgia Tech for my undergraduate” (EE7). Attending one of the top engineering schools in the U.S. influenced her career motivation.

C. Summative View

Each participant mentioned a component of the SEVT framework in their response as shown in Figure 2, demonstrating the applicability of the theory when considering motivation in engineering. Each node cluster in the Figure 2 represents one participant and the codes assigned to his/her response in the smaller nodes surrounding the central node. Male participants are represented by blue clusters, and female participants are represented by red clusters. The size of the nodes demonstrates the frequency of the code in the response, with a larger node indicating more coded statements. Some participants had lengthy responses that included several statements coded according to the theory, while others had limited responses and a small number of coded



Participant	Expectancies for Success		Subjective Task Value			
	Achievement	Extrinsic Validation	Cost	Utility	Attainment Value	Intrinsic Value
EE1					1,0	0,2,2
EE2					0,1	
EE3	1					2,0,1
EE4				1		1,0,2
EE5	4	1	0,0,2	3	2,0	2,3,1
EE6		1		1		
EE7	1			1		1,0,0
EE8	1				1,0	0,1,1
EE9		2		2		1,0,1
EE10		1				0,0,1

Figure 2: Representation of participants' coded responses with the size of each node reflecting occurrence of the subcodes. Blue nodes indicate male participants, and red nodes indicate female participants. Number of statements coded in each participants' response are displayed in the table with commas separating the subcodes. The subcodes for Cost read Opportunity, Psychological, and Effort from left to right. The subcodes for Attainment Value read Agentic and Communal from left to right. The subcodes for Intrinsic Value read Communal, Build/Create, and Interest in STEM from left to right.

statements. EE5, for example, had statements coded as eight of the ten codes from our structure with more than one statement coded as some of the codes, while EE6 had only two coded statements total. The occurrence of the subcodes for each participant are included in the figure. Three contributions to motivation from responses emerged as significant findings: the two components of participants' ES and the effect cultural context has on a STV. We noticed a distinct pattern of ES being based on either personal achievements or extrinsic validation. Seven statements were coded as personal achievements, and five statements were coded as extrinsic validation with female participants more often mentioning extrinsic validation as a motivator. Six of the seven personal achievement statements were made my males, while only one of the five extrinsic validation statements was made by a male. Both males and females depend on personal achievements and extrinsic validation to shape their confidence in an engineering field, but more females included stories of extrinsic validation as important factors. This difference is significant as we consider how to broaden participation. Additionally, we saw an unexpected relevance of cultural context. This again was not mentioned in the original SEVT, nor was it mentioned in other literature considered when choosing a framework for this research. Little attention is paid to cultural context in other works, so it was an unexpected, yet clear, pattern in participant responses. Seven statements were coded as cultural context in total, with four of the statements being made my males and three by females. It does not appear that cultural context influences males and females differently, but it does appear to be a factor. Location and family influences are significant in choosing a career in engineering. Actions cannot be made to affect one's cultural context, so it is again necessary to be aware of how an individual's cultural context does or does not influence them to become an engineer when considering how to broaden participation.

D. Implications for Broadening Participation

The inclusion of extrinsic validation in the females' narratives demonstrates that while it is important for females to have engineering related achievements, these achievements alone are not enough and should be recognized by others to further motivate them. Furthermore, the extent to which cultural context motivates both males and females demonstrates it could be a key motivation for all individuals. Although this finding aids in our understanding of motivation, the inability to intentionally alter one's cultural context limits its direct implications for broadening participation. Thus, for those lacking cultural context pushes to pursue engineering, other direct influences could be helpful and necessary to motivate them towards a career in engineering. Females who do not live with engineering as a part of their cultural context, for example, often will not consider a career in engineering without other explicit motivation. They often do not develop engineering identities because of the lack of other societal influences, so it becomes necessary for explicit intervention to introduce this possible career.

Recognition of engineering skills in females by others could overcome the potential lack of cultural motivators and increase women's expectancy of success in engineering. Educators at all levels should consider the potential lack of cultural motivators for women and seek to intentionally recognize engineering related skills in female students. Educators should encourage the development of both the professional and technical skills related to engineering observed in female students to broaden participation. Female students should be encouraged to pursue math and science skills as well as communication and teamwork skills necessary for an engineering role. Recognition should not be limited to technical skills often correlated with success in an engineering field. Helping a friend solve a problem may be a better marker of future success as engineer than having the best individual test grade. Recognition should also not be limited towards college students. Students of all ages should be encouraged, beginning in elementary school. Math, physics, and science identities significantly contribute to a choice to pursue engineering, and these identities should be encouraged at a young age to overcome other societal barriers to pursue engineering [27]. Elementary educators should recognize engineering related achievements in both girls and boys to combat a common experience that male students receive more attention in class and to limit the effects of stereotypes of girls and engineering discussed previously [28]. Elementary educators should also consider promoting growth mindsets – the belief in the potential for intellectual growth – when recognizing their students' achievements [28]. Math self-concepts of ability and math STVs often decline by the end of elementary school and throughout middle school, and a growth mindset could provide the foundation necessary to persist with stronger efficacy and performance in these stages of critical cognitive and identity development [4], [15], [29]. Learning environments affect an individual's learning mindset thus potentially providing girls protection from beliefs and stereotypes that girls are not as good as boys at math [4]. These suggestions of recognition and extrinsic validation if implemented in elementary school and all levels of education could provide more girls the motivations to become engineers. Thus, more girls could have similar motivations to those discussed by the female participants of this study. Although educators have limited influence on the encouragement of a student from family and friends, it could be helpful to additionally be aware that these groups impacted our participants decisions to pursue engineering.

Engineering groups, departments, and institutions might consider how to most effectively contribute to females' expectancies for success and interest in the profession. For example, participating in outreach events can introduce females to engineering and foster developing STEM identities. Girls in Engineering, Mathematics, and Science (GEMS) outreach programs address the untapped pool of human resources that is females in STEM. The programs allows middle school girls to participate in hands-on STEM activities, meet women scientists, and develop interests in these professions in an all-female active learning environment [30]. Girls can learn about careers with low female participation and develop intrinsic values and expectancies for success without worrying about the perceptions of male students [30]. To introduce the provided suggestions for elementary educators, universities could offer Research Experiences for Teachers (RET) programs. RET programs allow teachers to participate in professional development while working closely with scientists and experts in the field [31]. Educators at the undergraduate and graduate level could inform elementary educators of the importance of extrinsic validation and suggest the implementations discussed to foster identities and expectancies for success in a career in engineering for young girls.

E. Limitations and Future Works

While our data set allows us to look at components of motivation experienced by both males and females, a larger data set would allow us to identify gender patterns more confidently. One such finding that will be explored with more participant responses is the communal nature of the profession. A large consideration when entering this research was the difference between communal and agentic goals in individuals. Four statements were made demonstrating agentic goals and one demonstrating communal goals. Each agentic goal was mentioned by a male, and the one communal goal was mentioned by a female. While not enough statements were made to confirm a relationship between communal and agentic goals in males and females, it is considerable how the perception of the field influences motivation to join it. Each statement was made to explain how they believed engineering would satisfy a personal goal whether communal or agentic, and other statements not coded as motivations also demonstrated the potential influence of the nature of the field. Two male participants mentioned how their perspective of engineering shifted after becoming an engineer. They mentioned that it was not until they became engineers that they realized the communal effects of engineering and the potential to better their community that engineering provided. The participants mentioned their shift in perspective in response to being asked about their motivation indicating the possibility that the communal nature of engineering would have been a motivation if they were aware of it before becoming an engineer.

Because of our limited sample size, we were also not able to consider a deeper exploration of intersectionality. It would be worth considering other facets of an individual's identity such as race, socioeconomic status, or disability status in conjunction with gender. We did not ask participants to provide socioeconomic or disability demographics, and because our analysis only contained statements from ten participants, we were not able to consider these factors. Future works should consider how these factors contribute to an individual's motivation to become an engineer.

While participants were encouraged to pursue engineering because of their math and science skills, no participants mentioned recognition or possession of professional skills such as being a good teammate or communicator. Successful engineering requires both technical and professional skills, but participants only mentioned experiences when technical skills (math/science) were recognized and encouraged. We were interested in the ways individuals experienced extrinsic validation, but a pattern of areas where validation was lacking also emerged and should be explored further. As we continue data collection, we will consider the effect of recognition on motivation as well as the specific traits that are being recognized. Our data collection will continue with more focus groups with engineering educators as well as practicing industry engineers. We will compare motivations from the larger data set in future works to further establish patterns of motivation to identify ways to broaden participation.

IV. Conclusion

Despite increasing participation in STEM, the gap in female participation remains especially large in engineering. Considering this large gap in representation, we asked two questions: what motivates an individual to become an engineer and how can this understanding help broaden participation in the field? The SEVT helped frame motivation, and we used this framework to understand specifically motivation towards engineering. We saw the development of expectancies of success through personal achievements and extrinsic validation. We saw the contributions to subjective task values: cost, utility, attainment value, and intrinsic value. We contributed specific attainment values of communal and agentic goals and specific intrinsic values of an interest in STEM, a desire to build/create, and most notably, the effects of cultural context. The impact of personal achievements and extrinsic validation supports previous literature that females depend more on extrinsic motivators rather than intrinsic motivators [19]. Cultural context was an unexpected result but contributes to the need of external validation for female participation. Females who do not grow up in an engineering culture are at risk of not considering the profession unless directly encouraged through recognition and validation of engineering skills. We expected to see a difference in communal and agentic goals among male and female responses. Participant responses were consistent with these expected themes, but we look to future work where we consider larger data sets to further explore such theories. Overall, these retrospective narratives provide examples of the specific ways individuals are motivated to become an engineer.

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