

## **AC 2009-1042: I'M GRADUATING THIS YEAR! SO WHAT IS AN ENGINEER ANYWAY?**

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# I'm Graduating This Year! So What IS an Engineer Anyway?

## Abstract

Drawing on current motivation and identity literature, this research examines students' perceptions of themselves as engineers in the future and how this shapes their choices to be engineers. The primary data for this study were interviews collected over a four year period with ten students. Using multiple case study methods, the interview data were qualitatively analyzed. Participants in this study included five men and five women at Technical Public University (TPub, pseudonym). The results support two assertions. First, participants' views of themselves as future engineers include being good in math and science, being good communicators, being good at teamwork and enjoying activities they believe engineers do, doing problem-solving and having/applying technical knowledge. Second, despite almost four years in engineering-related classes and activities, three of ten participants remain unsure of what it means to be an engineer. Research and classroom implications are discussed. This research is part of the Academic Pathways Study (APS) conducted by the NSF-funded Center for Advancement of Engineering Education (CAEE).

## Introduction

We often assume that graduating engineering students readily envision what it means to be an engineer and what type of work they will be doing as engineers in the future. How can we know if this is true? This research begins to answer these questions by aiming to understand undergraduate engineering students' perceptions of themselves as engineers in the future as well as by considering how these perceptions shape their choice to become engineers. Why might this matter?

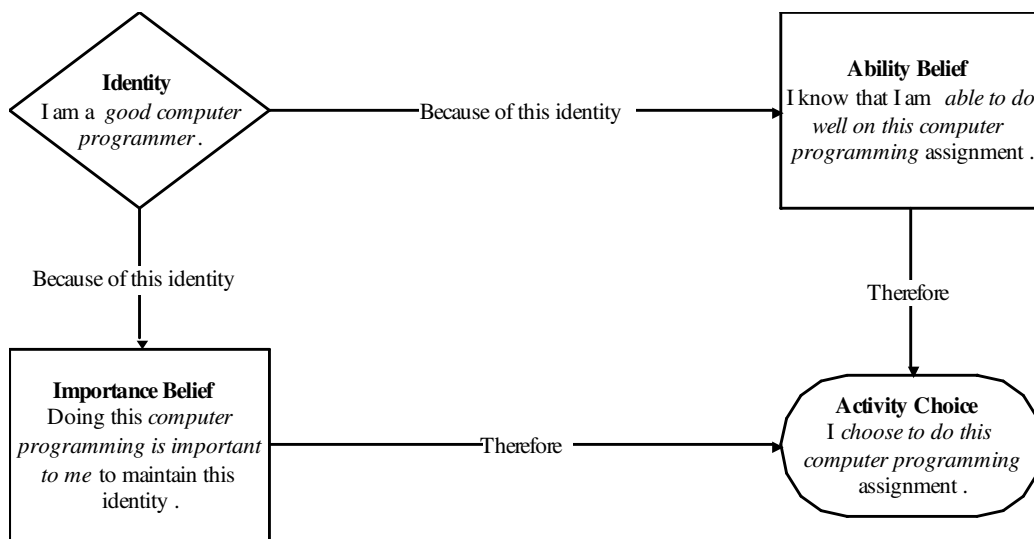
Our justification for this research is the need to understand, from the student perspective, the choice to become an engineer. Developing this understanding is key to answering recent calls<sup>1-5</sup> to increase the number and diversity of engineering graduates and change the way these graduates are educated and prepared for engineering careers. For example NAE<sup>3</sup> states that engineers of the future will not only have to be technically proficient, but also broadly educated and globally-aware for the jobs they are likely to face. However to attract and retain more students and to set educational and career goals for them, we need to understand why students choose to enter and persist in engineering programs.

## Theoretical Framework and Research Questions

The theoretical framework for this research is Eccles' expectancy-value model<sup>6,7</sup>. This model highlights ability beliefs, *how people judge their ability for a particular activity* and value or important beliefs, *how important an activity is to a person*. Eccles' model suggests that people typically choose to engage in activities 1) that they believe they can do well (positive ability belief) and/or 2) activities that are important to them (positive importance belief). Within this model, identity beliefs contribute to ability and importance beliefs. Identity is broadly defined as *the kind of person that one is now or wants to be in the future*.

Figure 1 demonstrates possible relationships between identity and importance beliefs. In this example, the key identity feature is “a good computer programmer”. As this figure shows, an individual believing that he/she is a good computer programmer might choose to complete a computer assignment because he/she knows he/she can do well on it. Similarly, an individual believing that he/she is a good computer programmer might choose to complete a computer programming assignment because he/she believes the assignment is important to complete or maintain this identity as a good computer programmer. Of course there are many other reasons why this individual might choose to complete this particular assignment, for example course requirements, making this choice process much more complex. This is just intended to serve as a simplified example of possible relationships between identity and ability and importance beliefs.

Figure 1: Possible Relationships Between Identity and Ability Beliefs



Similarly, there are numerous aspects of an individual’s identity that can shape equally numerous motivated behavioral choices. Therefore, choice processes are typically much more complex than this model shows.

This research begins an exploration of the choice process to become an engineer by examining identity and career choice as motivational constructs within Eccles’ expectancy-value theory<sup>6,7</sup>. More specifically, identity has been framed as engineering students’ perceptions of themselves as engineers in the future. Career choice has been framed as continued enrollment in an undergraduate engineering major. As discussed in greater detail in the following section, this research is grounded in the current literature in four ways. First, research within Eccles’ model shows that identity influences career-related ability and value beliefs and ultimately career choice. Second, career choice and identity share a conjoined theoretical and research history. Third, research demonstrates that future self-perceptions shape current actions. These first three contribute to the foundation for the research questions. Building on current literature, this research proposes to answer the following questions:

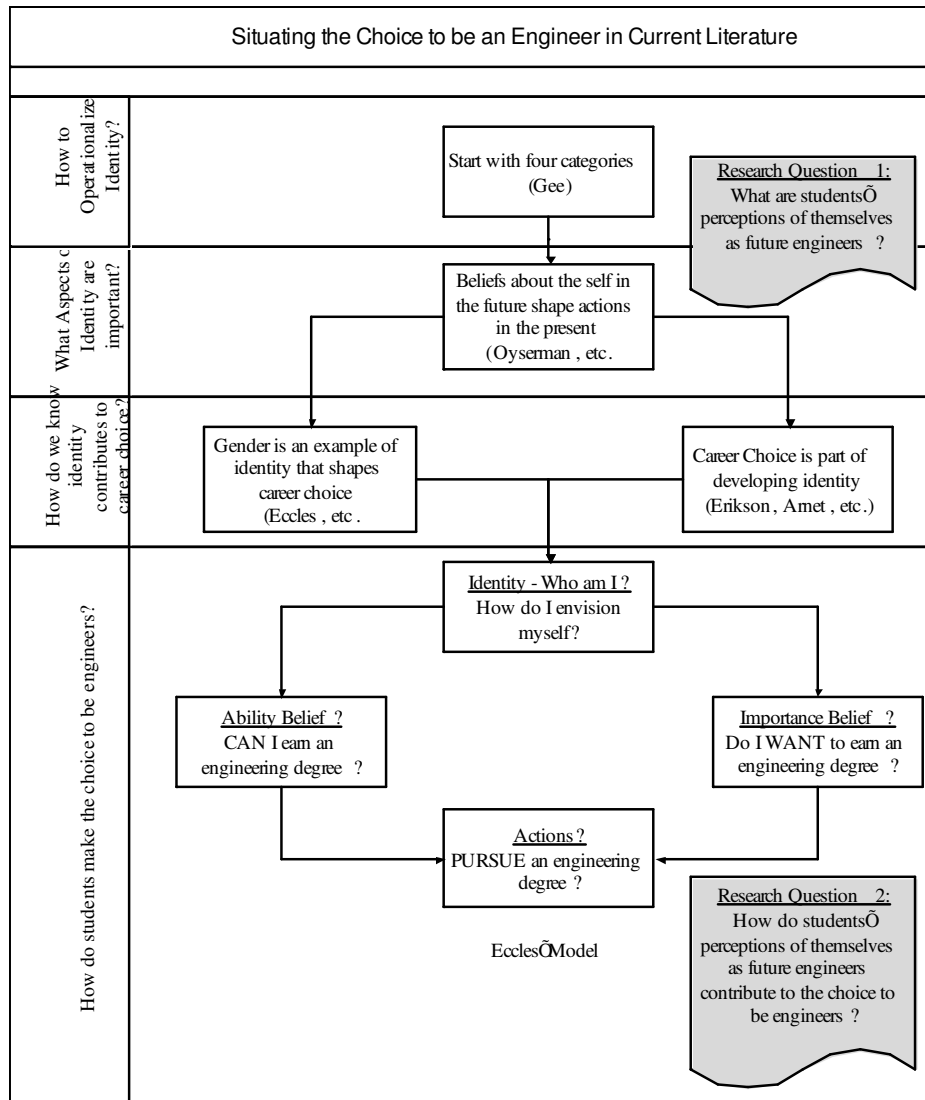
1. What are undergraduate engineering students’ perceptions of themselves as future engineers and how do these change over four undergraduate years?
2. How do these self-perceptions contribute to the choice to become an engineer?

The fourth connection to literature is related to data analysis. Using a current definition of identity helps operationalize this construct and facilitates data analysis.

### **Situation in Current Literature**

In this section, we situate this research with respect to current literature. Figure 2 shows the relationships between the current literature and the research questions with the research questions shown in gray. Starting at the bottom, the chart uses Eccles' model to show how identity contributes to the choice to be an engineer. The related research question "How do students' perceptions of themselves as future engineers contribute to the choice to be engineers?" is shown in gray. Moving up one level, we consider what the literature currently says about identity and career choice. Here we look to empirical research using Eccles' model as well as work by Erikson, Arnett and others. Moving up another level, we ask how we know what aspects of identity are important. Drawing on evidence from Oyserman and others we accept that student perceptions of themselves as future engineers are important in the decisions they make today, such as choosing to pursue engineering degrees. So our first research question (again shown in gray) asks "What are students' perceptions of themselves as future engineers?" Finally at the top of the chart we ask how we will operationalize these self-perceptions. Here we draw on Gee's conception of identity. These works are described in greater detail and cited in following sections.

Figure 2: Situating this Research in the Current Literature



### *Gender Identity and Career Choice within Eccles Model*

Eccles often uses gender and career-choice to exemplify the role of identity in behavioral choices [for example see references 7 and 8]. Eccles<sup>9</sup> describes gender as a “social system” (p. 44) which 1) influences an individual’s beliefs about his or her ability and values with regard to a particular career or range of careers as well as 2) his or her beliefs about the socially determined gender appropriateness of those careers<sup>9, 10</sup>. For example, enrollment rates in engineering suggest it is still a male-dominated career field<sup>4, 11</sup>. As the social system reacts to this discrepancy, some young women may start believing that they cannot (ability belief) or should not (social perception of appropriateness) work in engineering fields. Consequently such women may not want to be engineers (value belief) and may choose careers other than engineering (motivated behavior).

Causal relationships have not been established between gender and career choice within Eccles expectancy-value model. However, gender differences in competence beliefs, and values associated with career choice patterns (including course enrollment as precursors to career choice) have been identified. Research with children and college students show that women tend to have lower competence beliefs in math and science-related fields than men<sup>12-15</sup>. Research with students in grades K-12 on career-related values generally show no gender differences in interest in or importance or usefulness of math and/or science<sup>14, 16, 17</sup> although Linver et al found that boys' interest levels are more closely tied to ability beliefs than girls' interest levels<sup>16</sup>. Finally, Australian boys planned on and actually enrolled in higher levels of math classes and intended to pursue math-related careers more often than women<sup>18</sup> but American high school students showed no significant gender differences in math and science course enrollments<sup>14</sup>.

This research shows that gender, a component of identity, does contribute to shaping career-related competence and value beliefs and potentially course enrollments. Although to a much lesser extent, an ethnicity study within Eccles' expectancy value framework shows a relationship between ethnicity and valuing achievement<sup>19</sup>. Other aspects of identity have not been studied within this framework.

### *Identity and Career Choice*

With roots in Erik Erikson's<sup>20</sup> foundational theory, career choice has remained connected to discussions of identity development. In Erikson's theory<sup>20</sup> successful resolution of the identity crisis phase of development marks the end of childhood and the beginning of adulthood. Crisis resolution includes selecting and committing to a vocation<sup>20, 21</sup>. Marcia<sup>22</sup> operationalized Erikson's theory as a four-staged model with the lowest stage representing no identity crisis and no career choice and the highest stage incorporating resolution of identity crisis and career commitment. In this theory, identity and career choice are tightly linked.

In the 1970's and 1980's, many identity studies were conducted involving college students, the majority using Marcia's model [see 23 for a review]; this research was predominantly predictive and correlational. A meta-analysis of the results of these studies yields few conclusions mainly due to difficulties in isolating confounding factors such as maturation effects<sup>23</sup>. Nonetheless, college is believed to be a time of identity development<sup>24</sup> and a time of increased self-understanding among students<sup>25</sup>.

Current identity-related theories still incorporate an identity component related to career choice. For example, Arnett suggests identity exploration in the areas of love, work and worldviews is part of emerging adulthood, proposing a theoretically and empirically distinct life stage between the ages of 18 and 25<sup>26</sup>. As with Erikson's theory, Arnett theorizes that choosing a career is still related to the type of person one is and to the type of person he or she wants to be in the future. Identity remains difficult to operationalize beyond Marcia's<sup>22</sup> original approach.

### *Future Identities Shape Current Action*

Desires for the self in the future have been empirically shown to shape current behaviors. *Possible selves* are conceptions or representations of the self in the future<sup>27</sup> and “function as goals, having an incentive power to pull us towards a desired end state”<sup>28</sup>. Research has connected possible selves to academic choices and, as previously mentioned, academic choices relate to career choice. For example, an intervention to help students connect their future self and the current behaviors needed to achieve that possible self positively impacted their academic behavior<sup>29,30</sup>. Improved academic behaviors connect with students having plausible future selves<sup>31</sup>.

### *Operationalizing Identity*

As previously discussed, identity has not yet been operationalized in a broadly applicable, easily usable way due to the many confounding factors related to identity. This makes research on identity challenging. Although this study limits the scope of identity to the participants’ self-perceptions as future engineers, this one aspect can still encompass a broad range of individual beliefs. To further operationalize this aspect, we incorporated Gee’s<sup>32</sup> conception of identity.

Gee defines identity as “being recognized as a certain type of person”<sup>32</sup>. He profiles four different, but simultaneous and interactional identities, based on the process by which they come about, their defining power, and the source of that power. These identities are: 1) nature identity, 2) institutional identity, 3) discourse identity, 4) affinity identity. A single identity is an interconnection of all four identity types, although any particular one can dominate under specific circumstances.

Gee defined nature identity as “a state developed by forces in nature”<sup>32</sup>. An example of nature identity is a first born child who has this identity because of birth order which is an uncontrollable force. Being *an oldest born child* is an identity. An institutional identity is defined as “a position authorized by authorities within institutions”<sup>32</sup>. An example is a member of a fraternity where the identity of *fraternity brother* is granted by the governing body. There are certain rights and responsibilities associated with the fraternity and engaging in those rights and responsibilities becomes a part of the fraternity brother’s identity. A discourse identity is a trait recognized in the self and by others through a person’s combinations of speech and actions. For example, the student who continually takes charge in project groups and assigns tasks to others may develop an identity as *a leader* even without an election or other group consensus. An affinity identity is defined as “experiences shared in the practice of ‘affinity groups’”<sup>32</sup>. An example is a member of a stamp-collecting club who has an identity as a *stamp-collector* which is based on the perceived expectations or requirements associated with being a member of that group. While there may be no formal requirements, as with institutions, there may be perceived requirements such as attending stamp-collecting conferences.

Gee unpacks identity into distinct and defined aspects, yet these are not overly constrained or prescribed. These aspects served to help operationalize identity for this study by acting as a guide for categorizing data.

## Research Methods

In conjunction with the theoretical framework previously described, this research employed a multiple case (multicase) study research method. Together, expectancy-value and multicase methods frameworks shaped participant selection and data analysis choices. Examples of these choices can be seen through this section.

The data analyzed for this study were collected as part of a larger body of work, the Academic Pathways Study (APS), conducted by the NSF-funded Center for Advancement of Engineering Education (CAEE). Overall study design and data collection strategies have been described previously<sup>33, 34</sup>. Data collection specifically at Technical Public Institution (TPub, pseudonym) has also been described<sup>35</sup>. A subset of APS data was used in this analysis as described in the following sections.

### *Participants*

Participants in this study included five male and five female undergraduate students majoring in engineering programs at TPub. These ten students were purposefully selected from 16 possible APS participants who had engaged in semi-structured interviews. The ten represent those participants with a completed set of semi-structured interviews, i.e., one interview each year for four years. A total of nearly 40 students at TPub participated in APS but, by study design, not all engaged in the same data collection activities. The six possible participants not included in this study were missing interview data due to having chosen to leave APS, engineering programs or TPub. Throughout this paper, pseudonyms are used to prevent possible identification of the participants.

An important part of all case study-based research is establishing time and space boundaries around the event or phenomenon under analysis<sup>36, 37</sup>. The selection of these ten participants meets Stake's<sup>37</sup> recommendation to use five to 15 cases so that the cases provide sufficient but not overwhelming diversity related to the event or phenomenon<sup>37</sup>. In this analysis, each participant represented a case and each case was analyzed individually before all were analyzed together.

### *Data Sources and Collection*

The primary data for this study were semi-structured interviews conducted annually with all participants. The interviewers followed a loosely scripted set of questions but had the freedom to diverge from the list as deemed appropriate to probe for further information. The recorded and transcribed interviews were conducted in the spring for each of four years starting with the participant's first year at TPub (spring 2004). Sample questions include:

1. Think about your professors here at [Name of Institution]. What would you say they think it means to be a good engineer?  
How does that fit with your own image of a good engineer?



2. Okay, let's imagine it's a few years from now, and you've graduated with a degree in (student's planned major).  
What's next for you? (Or, if not planning on becoming an engineer, explore why they've made this decision.)
3. What do you imagine yourself doing on a day-to-day basis? (Or, if not planning on becoming an engineer: What do you imagine engineers do on a day-to-day basis?)
4. What would you say it takes to be a good (insert student's career choice)?  
How are you at (insert characteristics student mentions)?  
Are there things about yourself that you think you need to work on to become a successful (xxx)?

Entire interviews, not just responses to the questions listed here were analyzed.

In case study-based research, triangulation of data sources is an important aspect of quality research<sup>36-39</sup>. In addition to semi-structured interviews, some participants engaged in informal conversations. Different than the semi-structured interviews described above, the informal conversations were unstructured, occurred at irregular intervals and were not available for all ten participants. A total of 23 are available across seven participants. The informal conversations were used to triangulate the semi-structured interview data as described in the following analysis section.

### *Data Analysis*

Interviews were initially examined on a single case-basis and then themes were developed across cases. Interviews were read repeatedly to create a summary sheet for each participant. The summary sheet was based on Miles and Huberman's<sup>38</sup> "Contact Summary Sheet" used to capture "thoughtful impressions and reflections" and focus on the "primary concepts, questions and issues" (p. 52). In this analysis, the summary sheets captured salient information for each participant across the four years to identify themes and patterns related to their perceptions of themselves as future engineers.

All 40 semi-structured interviews were then coded using Atlas Ti software with open-coding strategies. Open-coding strategies identify patterns and themes related to the research questions that arise inductively from data rather than through application of theory<sup>40</sup>. This initial coding resulted in a long list of codes and associated definitions that grew with each successive interview analysis. To limit proliferation, the code list was refined by combining codes when they were judged to overlap sufficiently. The refined list was then reapplied to all 40 interviews. Following Miles and Huberman's<sup>38</sup> suggestion, the data were then organized into a graphical display (tables) sorted by participant to display codes and emerging themes.

Incorporating this display, a list of a priori codes was created. Starting with the literature definitions for Gee's<sup>32</sup> four identity components, operationalized definitions were created by comparing the literature definitions to the inductively developed, broad codes and grouping them into appropriate categories. Table 1 shows the codebook.

Table 1: Codebook

| Identity Category | Literature Definition   | Operationalized   | Example Quote   |
|-------------------|---|---|---|
| Discourse         | An individual trait recognized in the discourse/dialog of/with rational individuals | An individual trait recognized in the discourse/dialog of/with rational individuals related to being an engineer    | A conversation with someone about being an engineer                   |
| Nature            | A state developed from forces in nature   | An ingrained trait or characteristic of an engineer that is believed not to be a matter of choice                   | Being good at math and science  |
| Institutional     | A position authorized by authorities within institutions                            | A trait or characteristic perceived to be needed in the context of being a working engineer in a particular setting | Being able to communicate ideas to people in the marketing department |
| Affinity          | Experiences shared in the practice of affinity groups                               | Engaging in an activity or process perceived to be engaged in characteristically by engineers                       | Engineers solve problems  |

The entire set of semi-structured interviews (40 total, 4 for each of 10 participants) was recoded using the operationalized a priori codes. At this point, the informal conversations were also analyzed (23 total) to verify that themes identified in the semi-structured interviews also appeared in the informal conversations. The coding output for each participant was examined by creating graphical displays for the four identity categories by participant. The graphical displays from each participant were then examined in a cross-case analysis to create a “meta-matrix graphic display”<sup>38</sup>.

In reporting results, direct quotes from the participants are used as evidence. The source of each quote is identified using the following format: (participant name-interview type-time of year, year of interview). The interview type is either SS to indicate the semi-structured interview or INF for informal conversation, the time of year is either spring (Sp) or fall (Fa) and the year is indicated as 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> or 4<sup>th</sup>.

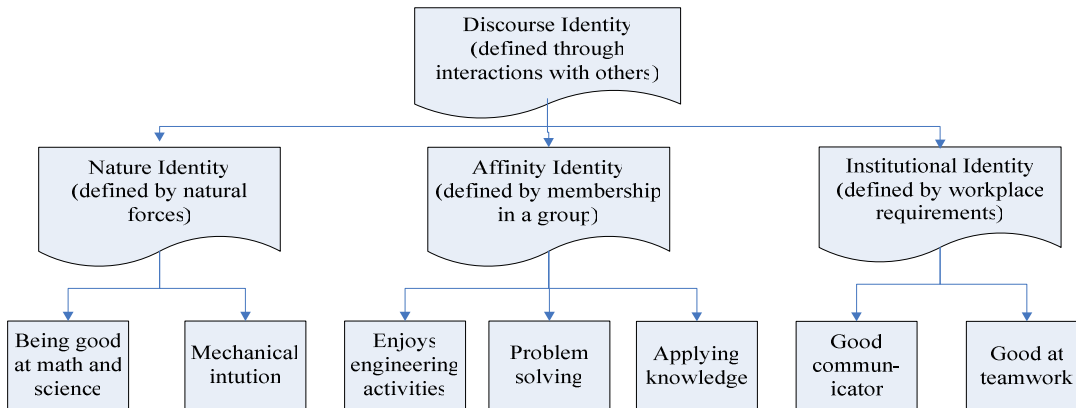
## Results

The results of this analysis support two primary assertions. First, the participants’ self-perceptions of being engineers in the future include visions of themselves as being good in math and science, being good communicators, being good at teamwork and enjoying activities they believe engineers do, doing problem-solving and having/applying technical knowledge. Second, despite almost four years in engineering-related classes and activities, three of ten participants remain unsure of what it means to be an engineer.

## Participants' Self-Perceptions of Being Engineers

As previously described, Gee's<sup>32</sup> four interrelated aspects of identity (nature, institution, affinity and discourse identities) were used in a priori coding. Within each coding category, e.g. institutional identity, the data were grouped into key themes found within that category across participants. Figure 3 shows a graphical representation of the results. Gee's four aspects of identity are shown presiding over more specific themes that emerged within each those aspects.

Figure 3: Identity Categories and Themes



From a longitudinal perspective, the categorical identity themes (e.g. being a good communicator) did not change over the four years. Participants generally continued to describe the same types of activities and characteristics as part of their self-perceptions as future engineers. These themes are discussed in greater detail in the following sections.

Discourse Identity- Figure 3 has a hierarchal organization. It is believed that discourse identity provides a lens through which *nature*, *institution* and *affinity identities* are viewed. Recalling that a discourse identity involves interactions with others, the primary data source, the interviews themselves, need to be viewed as a form of discourse. Via this interview discourse 1) the participants self report their perceptions of being engineers, and 2) the researcher views the participants. Therefore, the interview discourse becomes a discourse identity lens through which the other aspects of identity can be viewed.

This hierarchal view is believed to be permissible within Gee's<sup>32</sup> conception of identity because Gee describes the four aspects of identity in the following way:

They are four stands that may very well all be present and woven together as a given person acts within a given context. Nonetheless, we can still ask, for a given time and place, which strand or strands predominate and why<sup>32</sup>.

Because of the manner in which the data were collected and analyzed, we believe that allowing discourse identity to predominate is consistent with Gee's conception of circumstance-based interrelationships between his four aspects of identity.

Nature Identity- Nature identity is operationalized for this study as a perceived trait that is ingrained or characteristic of an engineer. In other words, this is not a matter of choice or level of effort. In this study, math and science ability was the most common nature identity. Seven of the ten participants talked about being good at math and science in one or more interviews. This quote from Mark exemplifies this theme:

I was good in math and science and I thought 'I want to do something with cars' so I figured engineering would be a pretty good, a great field. (Mark SS Sp 1<sup>st</sup> yr)

Mark's statement demonstrates the matter-of-fact language typical of this theme. Engineering is described as a natural outcome of math and/or science ability and importantly is not described as a reflection of working hard in or simply liking math and science.

Institutional Identity- In this study, institutional identity is operationalized as a trait or characteristic needed to perform an engineering job in a real or implied setting. Being a "good communicator" and "good team worker" are the two most cited themes grouped as institutional identity. Eight of the ten participants talked about good communications skills as being important in engineering careers. In this quote, Mark talks about the need for engineers to be able to communicate:

...you need to be able to communicate what you're thinking and be – if you're not able to tell – tell the person that's making it how to make it or tell the sales person, if you can't explain it to them it is never gonna work (Mark, SS, Spring 2<sup>nd</sup> year)

For Mark, being in a manufacturing setting means engineers must be able to communicate and share their ideas with production and sales people to successfully implement products.

Being good at teamwork is another theme within the institution identity category as stated by eight of the ten participants. In the following quote, Hillary talks about team work and problem-solving:

Like you're all comin' at this problem from different angles. And you all have different little parts of this problem. And then you meet and you try to figure out what's the best way to do it. And it is really cool. (Hillary SS Sp 3<sup>rd</sup> yr)

Hillary is describing an internship experience she had working as an engineer. In the context of her experience, engineers work in teams where everyone understands and addresses a different aspect of the problem but they work together to solve it.

With both communication and teamwork, the participants envision these as happening in particular settings, i.e., engineers at work. This connection to setting is what makes these institutional identities. Mark is thinking of engineers working in a production setting and Hillary is thinking of the engineers she worked with during her internship in the oil and gas industry.

While communication and teamwork are not characteristics unique to the engineering profession, the participants are relating these to the context of engineers doing professional work.

Institutional identity characteristics are distinguished from nature identity characteristics because institutional characteristics are not believed to be inherent and the participants believe they can improve such skills with practice. Institutional identity traits are also described as applicable to particular work settings, rather than the more universal applicability of being good at math and science as a nature identity trait.

Affinity Identity- For this study, affinity identity is operationalized as engaging in an activity or process perceived to be engaged in by engineers. For the participants in this study, three main affinity-related themes emerged including 1) having an interest or passion for math and science, understanding how things work, design, engineering, etc. 2) being a problem-solver, and 3) having and applying technical knowledge. At some point over the four years of interviews all ten participants reference each of the three affinity identity themes.

Within the first theme, *interest* and *passion* took different forms among the participants. However, the participants believed their *interest* or *passion* was shared among engineers. Within affinity identity, the actual interest or passion is less important than the perception that it shared among engineers. This quote from Joe demonstrates this theme:

I guess I have always been an engineering type person. I mean I growing up all my toys were like the Lego Technic stuff where you can design and build stuff. I had just about every construction set that they sold which was very fun. And then my grandfather was an engineer. I learned a lot from him, and I guess it's from him that I really learned that engineering was a profession and not just a fun hobby. (Joe SS Sp 3<sup>rd</sup> yr)

Joe is talking about being an “engineering type person”. He believes the types of toys he had, played with and enjoyed as a child contribute to this identity. He believes he learned about being an engineer from his grandfather, another engineer. He believes many of his hobbies correlate with the engineering profession and therefore mark him as an engineer. Joe’s passion for such activities alone does not make this an affinity identity, but rather it his implied belief that these passions make him similar to this group who call themselves “engineers” that makes this an affinity identity.

The second theme within the affinity identity category relates to problem-solving. Within this theme, it is not a passion for problem-solving that is highlighted but rather it is the actual act of problem-solving. All ten participants believe that engineers solve problems as part of their work. This quote from Tim describes how problem-solving *is* engineering:

...I mean it doesn't matter what discipline you're in it's; the way you think about the problem; and the way you approach it; and the way you try to solve it. That's all gonna' be consistent between engineering whether you're building a bridge, you're building a car, you're building a plane. “Alright, this is what I need it to do. This is the parts that I have, this is the money that I have. This is what it will do, this is what it can do. Now let's test it, will it really do this?” And that's, I mean that's the, the

whole, like the whole, like the whole scientific method, or whatever that is. And that's, I think that's the part of engineering that really attracts me. It's here's a problem, now fix it. (Tim, SS, Sp 3<sup>rd</sup> yr)

For Tim, part of being an engineer is solving a problem in a particular way. It is his perception that all engineers solve problems the same way. It is that perception that makes this an affinity identity.

Finally the third theme recognizes that having and/or applying technical knowledge as an important skill or trait of engineers. This quote from Will demonstrates his beliefs about engineers having knowledge:

I think of an engineer as while being specialized, still knowing something general about the overlapping fields. (Will, SS, Sp 3<sup>rd</sup> yr)

For Will, an engineer has both specific knowledge about his or her field and has general knowledge about other overlapping fields. He believes this is a common, shared trait among engineers. Participants described *applying* knowledge similarly and often together with *having* knowledge.

A commonality among the affinity identity themes is the participants' perception that these are things that all people who call themselves engineers do to be part of a shared membership in this group called "engineers". Affinity identity is distinguished from institution identity because the affinity traits are perceived as universal and are not associated with working in specific environments. Affinity identity is distinguished from nature identity because affinity identities represent activities one chooses to participate in rather than being inherent traits.

### *Uncertainty*

In addition to the themes related to Gee's aspects of identity, this research identified a theme of uncertainty about what it means to be an engineer. Three participants, Tim, Anna, and Marie, have lingering or persistent uncertainty about what engineers do throughout their four years. These participants do describe nature, institution and/or affinity identities. However, they also repeatedly report not knowing what engineering is or what to expect in the future. For example, in his fourth year, Tim says, "Like, I don't know what I'm gonna' do as a [major]. There are different options but the only reason I know that is 'cause of my internships." When asked if she has the skills to succeed in engineering, in her third year Anna answers, "I don't really know what to expect so it is hard to say for sure, like, 'Yeah, I'll be great'". Marie says, "...and the whole deciding your life direction wasn't easy this year. 'Cause I'm not looking at a person who has a vision of me really ten years from now." These quotes are just examples that demonstrate that the students have uncertainty about what it means to be an engineer and what type of work they will do as an engineer. These participants do not have clear, stable perceptions of themselves as engineers in the future.

### **Discussion**

This research has implications for both future research and for practitioners as described in the following sections. For future research, we begin to define an aspect of identity, self-perceptions as a future engineer, in a way that could be useful for developing quantitative identity measures. Also by demonstrating that some students are still uncertain about what it means to be an engineer even into their third year, we open the door for future research questions as well as considerations for practice. As researchers, we need to ask how our students learn what it means to be an engineer and conversely why uncertainty persists for some students. For practitioners, we need to ask ourselves what messages we are sending about being engineers and if these are the right messages. We also need to understand what this uncertainty could mean for our students.

### *Operationalizing Identity for Quantitative Research*

The participants' perceptions of being engineers can be categorized into Gee's<sup>32</sup> four interconnected aspects of identity and sub-divided further into themes within these categories. These themes are each expressed by more than half of the students. Further, they remain constantly present across the four years. Therefore, this research begins to operationalize an aspect of identity, self-perceptions as a future engineer, in a way that could be useful for quantitative measures within the expectancy-value model.

Identity is difficult to conceptualize<sup>41</sup>. Many college student identity studies in the 1970's and 1980's used Marcia's model (based on Erikson's theory) to correlate with, or predict outcomes or behaviors from, particular stages of identity development<sup>23</sup>. In the 1990's, the focus shifted from empirical studies to theoretical writings<sup>25</sup>. Specifically within engineering education, much of the work has qualitatively examined broad aspects of identity such as how engineering students identify themselves<sup>42,43</sup>. Moreover, identity development has proven difficult to isolate from confounding variables<sup>23</sup> and difficult to quantify meaningfully. However, quantifiable measures of identity are needed to enable studies with larger sample sizes and diverse populations. Such studies would increase the descriptive and explanatory power of Eccles'<sup>9</sup> expectancy-value model by empirically identifying relationships between identity and competence/value beliefs and associated action choices.

This research begins developing measures of a specific career-related conception of identity, by describing the self-perceptions of engineering students as future engineers. Defining and categorizing the identity-related characteristics provide the first steps on which future research can expand.

### *Uncertainty About Engineering*

Three out of ten participants in this study remain uncertain about what engineering is even by their third or fourth year of engineering undergraduate education. This uncertainty can have implications for engineering students, educators and researchers.

Uncertain students, i.e., those students without stable self-perceptions as engineers in the future, may lack a goal towards which they can act and assess progress. Research in possible selves shows that future self perceptions alone are not enough to influence behavior. Future self-

perceptions must be linked with strategies for working towards that future possible self<sup>29</sup> and must have a self-regulatory component to influence behavioral change<sup>31</sup>. Because this could ultimately lead students to leave engineering majors and the profession, researchers, educators and employers need to better understand the implications of such uncertainty.

Given Williams’<sup>44</sup> suggestion that there is an “identity crisis of engineering,” it should not be surprising that some engineering students lack a clear vision of themselves as engineers in the future. Because engineering, science, technology and management are blending into a whole, she believes that the formerly well-defined boundaries around what constituted engineering are becoming less distinct. As engineering expands and career trajectories become increasingly complex it can be expected that students will find “engineering” increasingly difficult to visualize and navigate<sup>44</sup>. As students are faced with ever more complex career possibilities within engineering, educators need to help raise students’ awareness for these opportunities and actively help them connect course content to the actual work of practicing engineers. This could help students develop a more specific vision of themselves as engineers in the future enabling them to develop the strategies and self-regulated behaviors needed to fully engage pursuing engineering careers.

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