AC 2008-960: BEING AND BECOMING: GENDER AND IDENTITY FORMATION OF ENGINEERING STUDENTS

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Being and Becoming:
Gender and Identity Formation of Engineering Students

Background:

For undergraduate engineering students, development of an engineering identity is an important outcome of their education, as they progress towards their professional selves. This process is reflected linguistically in engineering colleges, where engineering students are frequently referred to as "engineers" even in the earliest days following matriculation (in contrast, for example, students of history are never referred to as "historians"). This progression towards a professional identity is predicated on an understanding of what engineers do, and accepting characteristics associated with this identification.

Acceptance of professional identity has been shown to occur earlier for engineering students than for non-engineering students [Ngambeki *et al.* 2006]. This may occur because the curricular characteristics of most engineering programs may foster a sense of isolation from the rest of the academy. These characteristics include the large number of courses taken within the major, lack of course choice, and interconnectivity of courses with many prerequisites [Nespor 1990, Tonso 2006]. In addition, the rigor of many engineering programs and the need for collaborative work fosters a strong sense of camaraderie [Dryburgh 1999]. All of these factors are reflected in the constructed culture of engineering schools; in order to foster the development of an engineering identity, the culture of engineering schools frequently revolves around the idea that engineering students are 'different' from other students. This manifests in ways such as overt displays of group belonging (such as school jackets or t-shirts) or pride in isolation from the rest of the academy [Dryburgh 1999, Godfrey 2001].

Given the gendered history of engineering schools and their cultures, we hypothesize that men and women develop engineering identities in different ways. Here, we present data from the Academic Pathways Study (APS) that explores the complex interactions between gender and engineering identity. [Stevens 2007] The APS is a component of the Center for the Advancement of Engineering Education (CAEE), and specifically addresses questions about undergraduate students' experiences and decisions to pursue and persist in an engineering degree, relative to their learning and identity development, as they acquire the necessary skills to be professional engineers [Sheppard 2004]. With respect to identity, APS asks the following questions:

- *How do students come to identify themselves as engineers?*
- *How do students' appreciation, confidence, and commitment to engineering change as they navigate their education?* [Eris 2005]

In the discussion following, will focus on the extent to which gender plays a role in the answers to these questions.

General Methods

The CAEE is a collaboration of scholars focused on the development of knowledge about engineering learning and teaching toward the improvement of engineering education [Sheppard 2004]. The APS research element of CAEE is a multi-institution, mixed-method, longitudinal study which examines engineering students' learning and development as they move into, through, and beyond their undergraduate institutions. Data were collected from students at each of four institutions (pseudonyms are used here): Technical Public Institution (TPUB), a public university specializing in teaching engineering and technology; Urban Private University (UPRI), a private historically black mid-Atlantic institution; Large Public University (LPUB), a large public university in the northwest U.S.; and Suburban Private University (SPRI), a medium-sized private university on the west coast of the United States.

The APS uses a concurrent triangulation mixed-methods design, in which both qualitative and quantitative methods are employed to collect and analyze data. The integration of results occurs during the interpretation phase [Creswell 2003, Clark 2008]. This allows researchers to answer a broad range of research questions directed toward discerning complex phenomena like student learning and development [Johnson 2004]. Data were collected from students at the four institutions using surveys, structured and unstructured interviews, and ethnographic observations. Students were also asked to perform simple engineering tasks during timed sessions at the conclusion of interviews. The survey consisted primarily of closed-ended Likert scale questions. Structured interviews contained pre-designed, highly structured, open-ended questions. Unstructured interviews combined several pre-defined, open-ended questions with extemporaneous follow-up questions and prompts.

The study was designed to collect data from forty students at each of the four institutions (n=160). In each of the first three years of the study, structured interviews and performance tasks were to be administered to thirty-two of those students at each of the four institutions (n=128), and unstructured interviews and ethnographic observations were to be conducted with the remaining eight students at each institution (n=32). The survey was administered to all study participants either once or twice during each academic year. Sample sizes have changed during the first three years of the study as some students transferred out of their schools, the major, and/or the research project. In April 2007, a modified version of the survey was deployed to a broader, cross-sectional sample of the students at the four institutions (n=842). These students had not previously taken the longitudinal survey and represented a comparable sample of students from these institutions. Data analysis for each of the methods is ongoing.

I: Survey Questions on Group Identification

A series of questions (items) designed to assess group identification with engineers and engineering students was administered to the longitudinal cohort of students twice, once in the first year and then again in the sophomore year. Four constructs comprised a number of items; a full list is given in Table 1. Three of the constructs used to explore specific dimensions of engineering identity are based on constructs found in the Multidimensional Inventory of Black Identity [Sellers *et al.* 1997] These subscales focus on:, the extent to which the student defines himself or herself as an engineer ("centrality"), the extent to which the student feels positively or negatively about engineering and engineers ("private regard), and the extent to which the student perceives others feel positively or negatively about engineering and engineers ("public regard"). The fourth construct is based on an adapted version of a group identification scale [Hinkle *et al.* 1989; Brown *et al.* 1986] and is aimed at exploring the value individuals place on being an engineer and the emotional-affective dimensions of belonging to this group.

The items used a Likert scale, and responses were scored on a scale of 0 ('strongly disagree') to 6 ('strongly agree'). Responses were summed for each construct: centrality, private regard, public regard, and group identification. In addition, the centrality, private regard, and public regard scores were summed to provide a multidimensional total. Unpaired t-tests were then used to probe differences in responses between male and female students in the first year and in the sophomore year. Unfortunately, we do not have data for the junior or senior year.

In general, there were few differences between men and women in their identification with engineering students, at least at these two time points. There were no statistically significant differences observed between construct scores for men and women for the survey administered during the first year. However, some trends ($p < 0.1$) towards differences were observed during the sophomore year. Women reported a higher degree of centrality of engineering identity than men ($p = 0.1$), and men reported a higher perception of public regard for engineers than women ($p = 0.07$). There were no other differences observed.

Previous work on gender and engineering identities suggests that women may approach engineering culture, which incorporates masculine values, norms and assumptions, in a number of different ways. One common approach is for women to downplay their gender identity and adopt masculine attitudes and behaviors [Du 2006, Phipps 2002, Stonyer 2002, Walker 2001]. This can be interpreted as women adopting 'legitimizing identities' (that is, identities that are consistent with the dominant culture) [Walker 2001]. One of the ways in which this manifests is in showing solidarity with fellow engineering culture; for example, by downplaying observed sexist behavior as an 'exception' [Dryburgh 1999].

A more nuanced approach to the question of identity formation is to consider the development of a sub-identity within an overall framework of engineering identity. This is the approach taken by Tonso [2006] (Nerds, Academic-Achievers, Greeks), and by Stonyer [2002] (scientists, servants, citizens; almost guys, help-mates, power-puff girls). Many of these sub-identities revolve around the tension between the 'technicist' view of engineering, which has been traditionally masculine, and the view of engineering practice as consisting of a range of both technical and socially-oriented activities [Faulkner 2007]. This tension of identity that arises from different perceptions of what constitutes engineering, and how these interact with gender roles, is the subject of the next sections.

Table 1: Group Identification Survey Items

Construct 1: Centrality

*Overall, being an engineering student has very little to do with how I feel about myself.
In general, being an engineering student is an important part of my self-image.
My destiny is tied to the destiny of other engineering students.
*Being an engineering student is unimportant to my sense of what kind of person I am.
I have a strong sense of belonging to the engineering student community.
I have a strong attachment to other engineering students.
Being an engineering student is an important reflection of who I am.
Being an engineering student is not a major factor in my social relationships.

Construct 2: Private Regard

I feel good about engineers.
I am happy that I am going to be an engineer.
I feel that engineers have made major accomplishments and advancements.
*I often regret that I am going to become an engineer.
I am proud to be an engineer.
I feel that the engineering community has made valuable contributions to this society.

Construct 3: Public Regard

Overall, engineers are considered good by others.
In general, others respect engineers.
*Most people consider engineers, on the average, to be more ineffective than other professionals.
*Engineers are not respected by the broader society.
In general, other professionals view engineers in a positive manner.
Society views engineers as an asset.

Construct 4: Group Identification

I identify with engineering students.
I am glad to belong to a group of engineering students.
*I feel held back by engineering students.
I think engineering students work well together.
I see myself as an important part of engineering students on campus.
I fit in well with the other engineering students.
*I consider engineering students to not be important.
*I feel uneasy with other engineering students.
I feel strong ties to engineering students.

**Indicates that scoring for these items was reversed.*

II: Perceptions of engineering and of engineering design

Faulkner [2007] describes the practice of professional engineers as a tension between being a ‘technicist’ and the true ‘heterogenous’ nature of their work. Both men and women see technical work as ‘real’ engineering, and believe that one’s engineering identity revolves around technical skill. However, engineering practice requires many other skills which are not technically oriented. Engineers who were more focused on the non-technical aspects (such as project management or client liaison) felt that this had an impact on their identity as engineers.

Here we present some results that suggest men and women have different conceptions of engineering design, which we posit may have an impact on their engineering identity.

Defining and Doing Engineering

The definition of engineering varies widely and depends on its source and purpose. The National Academy of Engineering (NAE) acknowledges that engineering has been defined in many ways and adds that it is often referred to as the “application of science” because engineers take abstract ideas and build tangible products from them. Engineering is also defined as “design under constraint,” because to *engineer* a product means to construct it in such a way that it will do exactly what you want it to, without any unexpected consequences [NAE]. ABET states that engineering is “the profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the benefit of [hu]mankind” [ABET 2008].

We explored how students perceived engineering at various academic levels, and whether male and female engineering students had different understandings of what engineering is and what engineers do. Structured interview data were collected from study participants in their first, sophomore, and junior years. Study participants were asked, *“In your own words, would you please define engineering?”* Student responses were expressed across a wide range of anticipated responses and were captured as emerging themes (see Table 2). Some sample responses include:

- *“…I hardly thought about that before…designing new materials…” (Year 1 Female)*
- *“…an occupation that requires technical knowledge, critical thinking, and problem solving techniques” (Year 3 Female).*
- *“The practice of analyzing, and problem solving, and inventing, and building… creating” (Year 3 Male)*

Most Common Themes	First-Year Students (Year1)	Juniors (Year 3)
Designing/Creating/Building	40.5%	22.0%
Math and Science Application	21.6%	19.5%
Problem Solving	20.3%	28.0%
Improving Humankind	8.1%	13.4%

Table 2: Emerging themes in first- and third-year students

Data that emerged from the structured interviews showed that the designing, creating, and building aspects of engineering were identified most often (40.5%) by first-year students. Half as many students included the application of math and science skills (21.6%) and problem solving (20.3%) as part of their definitions in the same year. However, the number of third-year students who included designing, creating, and/or building in their definitions was markedly reduced, to only 22% of responses. Of the themes most commonly identified in the overall definition of engineering, problem solving and improving humankind were the only areas showing an increase, rising from 20.3 to 28% and from 8.1 to 13%, respectively.

The structured interview data revealed that a greater number of students defined engineering to include the action components of engineering (i.e. problem solving, application of math and science skills) in contrast to the thinking component of the definition (brainstorming, critical thinking). Themes that saw an increase in response between first and third year students included *problem solving* and *improving humankind*. The decrease in the frequency that students used *designing/creating/building* to define engineering was significant. In another analysis, we found that while most engineering students can relate to what engineers do and the skills required to be successful, they cannot always communicate or *define* what the discipline of engineering encompasses.

When we reviewed the data by gender, we found that male students perceived engineering in terms of math and science application to a greater extent than their female counterparts. Male respondents mentioned the ability of engineering to improve humankind in their descriptions. Here, *improving humankind* was used to describe a material or technological advancement. References to *designing, creating, and building* within the definition of engineering were associated with the process of physical or mental design, often entailing the visualization of engineering solutions.

These observed gender differences puts the nominally similar identification of women and men with engineering (as discussed in Section I) into a new light; since they have differing perceptions of engineering, the nature of what they are identifying with is presumably different. This is further developed in the following section.

Perceptions of Engineering Design

The longitudinal survey portion of APS included a question designed to elicit engineering students' conceptions of design. As shown in Figure 1, the closed-ended question presented a list of twenty-three design activities and asked respondents to choose the six they thought were the most important. This question is an extended version of an item used in Newstetter and McCracken's study of perceptions and misperceptions of the design process [Newstetter and McCracken 2001]. Items were added to the original list to reflect a broader array of design activities [Mosborg 2005].The design activities question was administered to APS participants in each year of their engineering study, allowing for longitudinal comparison of the responses. Here, we make comparisons between the first- and fourth-year responses [Morosov 2007].

Of the twenty-three design activities below, please put a check mark next to the SIX MOST IMPORTANT.

__ Abstracting
__ Brainstorming
__ Building
__ Communicating
__ Decomposing
__ Evaluating
__ Generating alternatives
__ Goal setting
__ Identifying constraints
__ Imagining
__ Iterating
__ Making decisions
__ Making trade-offs
__ Modeling
__ Planning
__ Prototyping
__ Seeking information
__ Sketching
__ Synthesizing
__ Testing
__ Understanding the problem
__ Using creativity
__ Visualizing

Figure 1. Text of the design activities task.

The first-year administration of the APS survey yielded 147 responses to the design-activities question that were suitable for analysis (*i.e.*, engineering students whose response contained exactly six selections from the list), with just over a third of respondents being women. Women and men were largely in agreement, with many students prioritizing activities such as "Understanding the problem," "Communicating," and "Brainstorming." However, there were some statistically significant gender differences. As shown in Figure 2, women were less likely than men to select "Building" and "Prototyping" and more likely to select "Seeking information" ($p < 0.01$, two-sided Fisher's exact).

The fourth-year administration yielded 103 responses suitable for analysis, again with women representing just over a third of respondents. Overall design-activity prioritization was similar to the first-year's administration. The gender difference in selecting "Building" from the first year was observed again, with women less likely to select this activity (note: there was no significant difference for "Building" between men and women in Years 2 and 3, although the trend persisted). In the only other significant gender difference, women were more likely to select "Goal setting." Figure 3 shows selection frequencies for all design activities, by gender.

Comparing these responses to the 'perception of engineering' question addressed in the first part of this section highlights an interesting difference; women were less likely to identify 'building' as an important component of design as early as the first year. However, both genders were less likely to cite 'designing/creating/building' as central to engineering in the junior year compared to the first-year. This suggests that not only do women and men have different ideas of what constitutes engineering, but that these perceptions change with time, and they may evolve differently for men and women. This further illustrates the complex nature of identification with engineering; in effect, engineering identity is a 'moving target.'

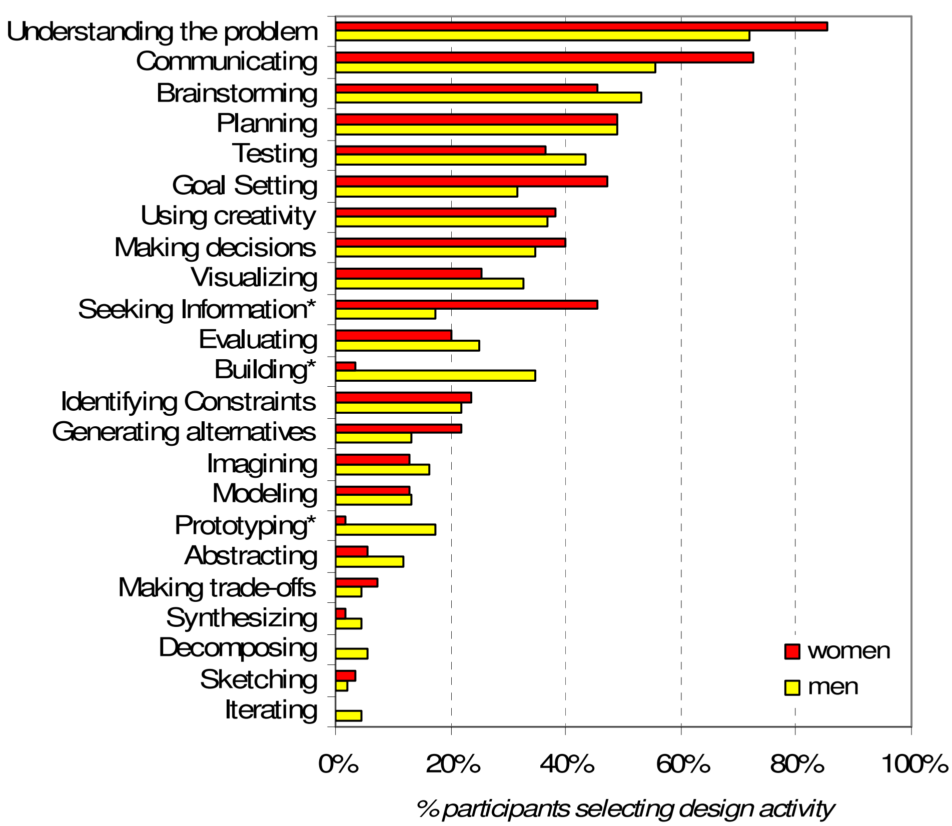

Figure 2. First-year engineering students' responses to the design activities survey question, by gender (*n*=142; 55 women and 92 men). For each design activity, bars show the percentage of women and men who included the given design activity among their set of six most important. Design activities are sorted by overall (women and men combined) selection frequency. Asterisks indicate design activities for which selection frequency was significantly different across gender ($p < 0.01$, two-sided Fisher's exact).

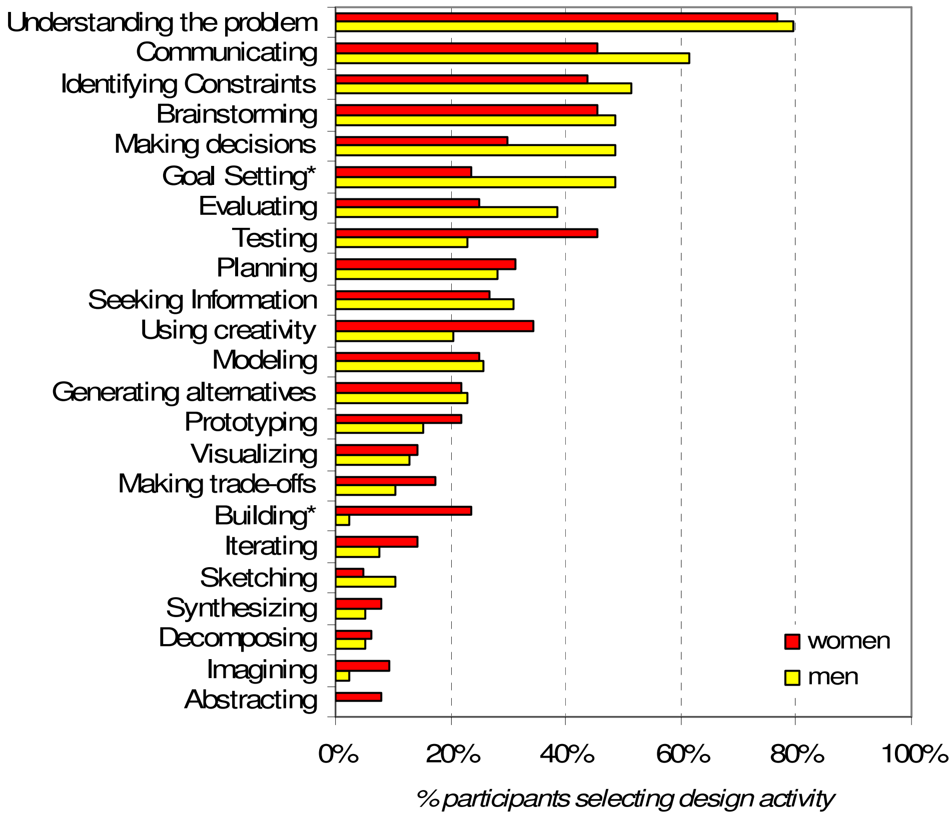

Figure 3. Fourth-year engineering students' responses to the design activities survey question, by gender (*n*=103; 39 women and 64 men). For each design activity, bars show the percentage of women and men who included the given design activity among their set of six most important. Design activities are sorted by overall (women and men combined) selection frequency. Asterisks indicate design activities for which selection frequency was significantly different across gender ($p < 0.01$, two-sided Fisher's exact).

III: Self-Perception and Engineering Identity

Differences in how men and women perceive themselves as engineers were elaborated upon by some students at Large Public University during a qualitative semi-structured interview in their fourth year. One young woman described how men in engineering get more respect than women, and how consequently they are more confident. Many of the respondents perceived that women had an advantage over men, with respect to opportunities for scholarships, internships, and jobs. This led to perceptions that women did not necessarily merit the recognition they received. One male respondent complained that a woman in his class received an internship that he was not even interviewed for, despite his view that "I'm better for that job than she is….It made me wonder if…[the company] needs, they feel like they need to hire some women." Another woman felt privileged because it was simply a matter of numbers. She thought the company she had an internship with wanted to hire one man and one woman, "so I'm assuming me being a girl would help because there's less women applying for the job."

A female student felt that women's abilities were underestimated, and people were more likely to listen to men's opinions than women's. "That happened to me a lot, you know, I feel like we both know the same level of concept, but then [others] turn to listen to the guy more than the girl." She felt that differences in how men and women were treated led to differences in their confidence levels, which then led to differences in how they engaged in their engineering courses. She described, "Usually guys are like, you know, I'll just ask this question, and even if it is like, you know, a really bad question, even if people think it's a stupid question, [guys] don't care, you know, they just ask the question."

A young man admitted that "there's a beneath-the-surface idea that people might have, maybe not consciously but subconsciously, that girls aren't as good as guys at engineering." But, he added, "the way I try to approach it and the way that everyone I know in the department tries to approach it is not whether you're a boy or a girl, it's whether you're good at engineering or not." Indeed, many of the men who participated in the fourth-year interviews thought women could be just as good as men in engineering, but, as one man put it, "if they just had some confidence, sat down and did it, that—I mean I'm sure they could all do it, you know, just as well."

Another way that men and women may be different in how they approach engineering refers back to our findings about design activity priorities. Some women have described gendered differences in approaches to team projects. For instance, one woman described how

> *[G]uys are different from girls, when we're working on projects and stuff, and sometimes there's -- they have like one track mind where it's like let's just get through this and then we can go. And then—but then I guess when I'm in a group then I sort of have to pay attention to the little details surrounding it, like, oh, what about this, what about this, and maybe we have done this—maybe not get through everything in one sitting as they would like, but then consider more of the big picture sometimes.*

Another male student speculated that differences between men and women in their approaches to design problems stem from differences in their experiences.

It surprises me, even though it shouldn't, if like a girl has a ton of machining experience. Like I always find it kind of surprising at first, or if it's not someone who I know has had a ton of research experience so that's where they learned it. And I know that not a lot of the girls come in with like shop experience, and I think a lot of the guys do, because I guess that's the kind of thing boys do in high school or something.

These descriptions alone do not provide enough evidence that men and women engineering students have different levels of confidence and different approaches to engineering design problems. However, the gender gap in self-confidence have been demonstrated in previous research [Morosov 2008] and the qualitative data also support our findings that men are more likely to prioritize "building" as an important design activity (see also [Kilgore 2006]).

While it seems likely that self-confidence and the perception of competence relates to identification, the exact nature of this relationship is not well understood. Similarly, there is some evidence that the nature of students pre-engineering experience varies by gender, and the impact of this on the development on engineering identity is unknown.

IV: The Connection between Identity and Commitment

The mark of a student's connection with a particular course of study can be measured using several variables. Hartman and Hartman [2006] used engineering self-confidence, educational background, and involvement in extracurricular activities, among other variables, to determine reasons why students remained in their respective engineering programs [McCain 2007]. Swail [2003] included academic preparedness, the attention paid to diversity, and students' commitment to their academic goals as factors of commitment. As part of the APS, students were asked about their level of commitment to completing the engineering major and their intentions to use the degree after graduation.

Responses to the Structured Interview question: *How committed are you to pursuing an engineering major? And why?* were coded and then given a numerical value. An example of a statement coded as "very committed," and the reasons for the response provided by a third year female student follows:

[I am] "very committed. I've made this decision to pursue engineering, and though it's not concrete, the more that I take classes, the stronger the desire I have to become an engineer. So at this point, I've learned enough to really solidify my decision to become an engineer. So I'm very committed to completing my coursework."

Responses from 60 "core" students from their first, second, and third years of study are found in Table 3, below.

	YEAR 1 2004		YEAR 2 2005		YEAR 3 2006	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Very Committed	27	45.0	49	81.6	52	86.7
Somewhat Committed	27	45.0	8	13.3	6	10.0
Not Very Committed	2	3.3	0	0.0	2	3.3
Not Committed	1	1.7	1	1.7	0	0.0
Invalid Response	2	3.3	1	1.7	0	0.0
No Response	0	0.0	1	1.7	0	0.0
Don't Know	1	1.7	0	0.0	0	0.0
	n = 60	100%	n = 60	100%	n = 60	100%

Table 3: How committed are you to pursuing an engineering major? [McCain 2007]

Future Plans of Engineering Students

The majority of study participants planned to work or pursue an advanced degree after completing their undergraduate engineering degrees. The persistence and maintenance of engineering majors is of critical importance to the engineering community. Students that enjoyed their educational experience and that planned to go to graduate school totaled 35.7 percent. Conversely, students that placed greater emphasis on areas of dissatisfaction with their degree programs and were more likely to join the workforce totaled 60.7 percent. The remaining students were either undecided or planned to take time away from engineering altogether.

While 86.7 percent of junior engineering students stated they were "very committed" to completing their engineering education, this did not necessarily mean that they were planning to remain in the engineering profession. What does this mean when exploring the significance of developing an engineering identity? Is there a difference between identification as an engineer in the academic sense (i.e. as an engineering *student*) and professional identification as an engineer?

IV: Engineering Identity and Non-Engineering Activities

Data from both surveys indicate that females are more likely than males to report feeling overwhelmed by engineering coursework. Despite this, women identified the engineering campus culture, as well as the challenge of becoming an engineer, as aspects they liked. Women also report higher levels of fulfillment from extracurricular engagement; early analyses indicate that women seek more extracurricular opportunities to complement their academic pursuits, suggesting a need for broader experiences [Loshbaugh 2006]. In the broader core schools sample, this was true of extracurricular involvement in engineering and non-engineering activities. In ethnographic data, women more frequently reported feeling academically "burned-out"; men expressed less dissatisfaction with the workload.

The methods we have discussed to this point paint broad strokes about the experience of engineering students; however, clearer understanding about what this means for an individual is possible through analysis of ethnographic data. At Technical Public Institution, nine students—four female and five male (this number includes one replacement for a participant who left the institution) engaged in the ethnographic component of the study. While the total number of participants was nine, at any given time, only eight students were active. Thus, we refer to the total active number as being eight. Of the eight, only two (one woman and one man) were decidedly committed to engineering as a discipline and remained intently focused on becoming engineers. The remainder of the students wavered in both their desire to practice engineering and their pursuit of the necessary steps to become engineers.

We will briefly describe the paths of the two intently committed engineering students, Hilary and Max, and describe in greater detail those who were less direct about becoming engineers. Hilary and Max each chose an engineering discipline in the petroleum extraction and refining arena; each had a parent with engineering or geosciences expertise. Each chose internships in related fields for every summer and some holiday breaks. Neither was terribly distracted by other majors and neither was crushed by the volume and pace of engineering studies. Each saw the difficulty of engineering college as short term and something they could endure in order to achieve the goal of becoming an engineer. [Kilgore, 2007]

In fairly stark contrast are four other TPUB students discussed here. To varying degrees, each struggled with whether or not they had made the right decision to enroll in engineering studies or to become engineers. Michael and Tad report fewer instances of overwhelming doubt about becoming engineers and seem overall more willing to entertain engineering identity as a possible fit. Nevertheless, neither of them progresses as directly or with the same clarity as does Max. Leslie and Anna express great doubt about their choices, even as they are graduating with engineering degrees; their identities as engineers are never as clear as Hilary's.

Michael's grandfather was an engineer, and a high school mentor had recommended that he attend TPUB. Michael disliked the narrowness of the TPUB technical curriculum and was bored with the expectation that homework was the chief outlet for TPUB students—even on nights and weekends. "It's Friday night; I'm not going to stay home and do math," he said. "I can do the math," but he preferred the availability of other pursuits, both intellectual/academic and leisure. He had participated in high-level theater and music performances as will as college-level humanities studies in high school and found the narrow scope of an engineering intensive curriculum to be too constraining. The confined identity of an engineer as someone who focuses exclusively on engineering work was not a good fit for him. Michael transferred at the end of his sophomore year from TPUB to another engineering college within a larger institution that gave him more options for non-engineering coursework. During his exit interview from APS, Michael was studying an engineering major at his new institution and taking a broad array of humanities and general studies that TPUB had not offered.

Tad's grandfather also was an engineer. Tad had been encouraged to attend TPUB at a high-school college fair and was impressed by the phone call he received from a department chair shortly after the fair. He enrolled in a resource-extraction major, had attained a grade point average (GPA) above a 3.0 after his first year, pledged into a fraternity, and applied and received a position as a high profile and high responsibility student employee. However, as a sophomore, Tad spent a lot of time at his job and at the fraternity but significantly less time at his studies. He drank a lot, and at the end of the first term, Tad's cumulative GPA dropped to .8 out of 4.0. He lost his campus job and was placed on academic probation. At about that time, he also received his first position as an intern in a government sector position, unrelated to engineering. Tad reveled in the exposure of his internship and began to think about law school as a possibility. He also returned to TPUB and began concentrating on restoring his academic standing. Each semester and holiday break, Tad tried to get engineering internships but was unsuccessful, largely because of his low GPA. However, his government sector internship was always interested in having him back, so he kept returning. His interest in law school continued, even as he imagined what life would be like as an engineering executive. "I'd fly in on a helicopter in a suit, with the hard hat, of course, say something like, 'Good work, here; keep it up,' and get back on the helicopter to fly on to another site." Given his plummeted GPA, Tad was not on track for a four-year graduation date; during his final interview at the end of his fourth year, a professor had suggested he apply for graduate school in the same department. He was thinking about completing his Master's degree, working for a while, and then going to law school—or simply going straight to law school and then becoming a lobbyist. The narrowly technical aspects of engineering identity were not a good fit for his grand vision of his future.

The women, Leslie and Anna, each completed engineering degrees in four years, maintaining GPA's above 3.6, while pursuing extracurricular activities or work experiences. These women's engagement with their academic experience and success in their coursework would suggest that they were better prepared to become engineers than their male counterparts. However, their satisfaction with the choice to study engineering and interest in pursuing engineering practice after graduation are even more indeterminate than those of the TPUB men in this study.

Leslie entered TPUB planning to use engineering to further her religious faith serving impoverished and needy communities with her technical skills. She loved mathematics and was interested in her TPUB math courses; applying the math to engineering problem solving was much less attractive, in her perspective. Leslie was active in faith-based student groups, taking leadership positions and traveling to perform community service during school breaks. She also enrolled and was actively involved in a humanities-based minor. Leslie experienced several crises of commitment to her degree choice and to her religious faith, often questioning "what God wants me to do," both spiritually and academically/professionally. Leslie participated in two summer internships, finding them both to be helpful in defining what she did not want to do upon graduating from college: practice engineering. In both cases, she felt isolated from the office community. One internship was through a governmental agency for which she spent the summer drafting plans using AutoCAD. The absence of community and the mechanical nature of her work defined for Leslie a professional experience she did not want to repeat. In the spring of her senior year, Leslie indicated that she wanted to take some time off after school before returning to college to earn a teaching certificate in mathematics; her strong interest in the field and her enjoyment of working with school children on a college project had led her to conclude that she wanted to become a teacher—although not right away. She did not regret her choice to study engineering, even though she did not intend to become an engineer. In her final interview, Leslie announced, "You're not going to believe this. I've decided that when I get back from my postgraduation trip with my mom, I'm going to look for an engineering job. I have to have a job, I have the training, and it'll pay better than Starbucks." This lukewarm entry into the engineering profession seems to have been an acknowledgement of a practical reality—needing income generated from work—far more than identifying herself an engineer.

When Anna enrolled at TPUB as a first-generation-to-college student, she had broad academic and pre-professional interests, including Physics, Psychology, Art, and Bio-medical studies. She enrolled in Physics, describing its content as "the base of all things," from which she hoped to pursue graduate work in Psychology or Bio-med. Anna had been recruited to TPUB because of her high GPA and strong math and science capabilities, but she knew little about the campus or its characteristics before she enrolled. She engaged in a number of campus activities and remained highly socially active throughout her undergraduate experience—although not as involved as she hoped she could be. She also sought outlets for her creative interests, such as painting and poetry, with greater or lesser success. During her sophomore year, Anna described her frustration with being unable to study in the depth or breadth she liked, given the vast amount of work her classes called for; she reported, "My little perfectionist just died." She also withdrew from her major and transferred to a different department because she found Physics to be unwelcoming and overly competitive. She considered transferring to a comprehensive university but was emotionally closely tied to TPUB because of all the activities she was enrolled in and had developed a relationship with another student in her major. As a junior, Anna decided to stick engineering out, even though she was not particularly interested in her new major. Perhaps, she thought, she would pursue an art degree for graduate school. She steadfastly refused to seek internships. As she was graduating and planning to move to a different state with her boyfriend for his new job, Anna was uncertain what she would do. She thought she might search for a job in engineering so that she could decide. Even with a degree in engineering, she did not identify herself as an engineer.

Observations from the in-depth review of the paths TPUB students took to become engineers parallel those of students at other APS institutions. The combined stresses associated with the demands of challenging coursework, the need to partake in social activities, and meeting family expectations all support the idea that the development of engineering identity is derived from numerous sources – both internal and external to the academic institution.

Discussion and Conclusions

To summarize our findings briefly, we observed that there was little difference in the degree of identification as an engineer between men and women, at least in the first- and sophomore year. However, men were more likely to perceive engineering as the application of math and science (that is, highly technical) and to prioritize 'building' as a design activity. These differences suggest that, when men and women express their degree of identification with engineering, they are actually identifying with a slightly different set of activities. In addition, men are more confident than women in their math and science skills, and women are perceived to be less competent than men, but the effect of this on the development of an engineering identity is unknown.

The development of an engineering identity is strongly fostered by the culture of engineering schools and is considered to be an essential part of the educational progress of students towards a professional engineering identity. However, data presented here suggest that the interaction of gender with the development of engineering identity is complex and multilayered. At its base, it requires a consideration of how men and women develop an understanding of what constitutes an engineering identity (for example, the conflict between technical work as "real" engineering and the heterogeneous activities comprised by engineering practice); this contrasts with the growing understanding of students, over the course of their education, that engineering practice extends beyond the technical aspects. It also requires an understanding of how students of both genders develop identities that relate to their engineering identity, whether it is identification, counter-identification, or dis-identification. While there were few observed differences in the self-identification of students in the first two years of their education, the gender differences in perception of what constitutes engineering and design (the males were generally more technically oriented) may affect engineering identification with engineering, in light of the 'technicist' viewpoint [Faulkner 2007]. In addition, the relationship between self-confidence and perception of competence on the development of identity is not well-understood, so it is problematic to evaluate the impact of gender differences. Some other research questions, not explicitly addressed here, include understanding the relationship between the development of engineering identity and:

- extracurricular activities, both within engineering (eg mini-Baja, solar cars, or volunteering with Engineers Without Borders) and outside engineering (eg theatre, other community service)
- exposure (or lack thereof) to engineering practice

As the nature of student understanding of engineering changes over time and differs between genders, a complete picture of how students develop an engineering identity is complex. The work presented here is only a preliminary examination of the process of identity development as students progress through their engineering education, The research of the Center for the Advancement of Engineering Education on how students' identity and commitment to engineering changes over time is ongoing.

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