

What Does It Mean to Be an Engineer? A Comparison of Adult Students at Three Institutions

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Abstract

Our work is motivated by the need to cultivate a diverse group of talented future engineers. Adult undergraduate students age 25 and over are an important source of engineers, with life experience that can enhance student experience, but not much is understood yet about this specific group. Adult students face challenges specific to their demographic due to responsibilities in other aspects of their life as employees, parents, spouses, and more. This paper examines adult engineering students' conceptions of what an engineer is, across three distinct academic environments: a community college, a small private undergraduate university, and a large public research university. A semi-structured interview approach was used to collect data from adult students with prior engineering-related work experience. These data reveal strong similarities among the conception of what it means to be an engineer, despite differences in the demographic background and institutional context of the participants. There are differences in courseload, employment status, and number of dependents among the sample populations at the three institutions. Participants from all institutions identified with occupational respect, application of knowledge to find solutions, benefiting society, and problem solving as important aspects of the engineering occupation. This work suggests opportunities to enhance professional identity development at institutions of multiple types through industrial collaboration and mentorship, policies and programs to support student-parents, and cooperative work opportunities that marry engineering education with engineering practice.

Introduction

Adult Students in Engineering

Engineers are expected to be able to apply technical knowledge to find creative solutions to challenging problems. One way to maximize problem solving capabilities of the engineering workforce is to increase diversity within the classroom and thereby improve the educational experience of all students. Extensive research has been conducted to study how ethnicity and gender affect an engineering student's experience, but little research has been done to focus specifically on adult undergraduate engineering student experience. Adult undergraduate engineering students are defined as students pursuing their first undergraduate engineering degree, and in this study are limited to students age 25 and older. The presence of adult students enriches undergraduate engineering programs because their added life experience allows them to approach their studies with unique perspectives, motivations, and strategies compared to their younger peers.¹ Because of the added challenges that adult students face, their presence in

undergraduate programs must be supported to improve retention of this valuable group of students.² Prior studies have shown that identifying with engineering is linked to both educational and professional persistence.³ Our research focuses on the development of engineering identity among adult engineering students.

Currently, adult students make up 37.6% of the student population at 4 year institutions in the United States and 40.3% of the population at 2 year institutions in the United States.⁴ Adult student enrollment rates are increasing on par with the rates of their younger, traditional counterparts, and the rate of increase of adult enrollment in college is expected to outpace the rate of increase in traditional age student enrollment. NCES projects that from 2012 to 2023 the rate of increase for students under the age of 25 will be 12%, whereas the rate of increase for students age 25 and older is projected to be 20%.⁵ However, little work exists that studies the engineering education experience of such a large student group. A report from the Multiple-Institution Database for Investigating Engineering Longitudinal Development indicates that adult engineering students have a lower graduation rate than their traditional engineering peers.⁶ This implies that the adult engineering student body experiences challenges specific to their demographic. Adult students are more likely to be married, have dependents, be financially independent, be enrolled part time, and be employed.⁶ Adult students enrolled full time are more likely to attend community college than a public 4-year college.⁷ Working full time and going to school part time are both factors that have been independently linked to lower rates of persistence and degree attainment.^{8,9}

Professional Engineering Identity

Developing an identity as an engineer has been linked to persistence in an engineering program. The acquisition of this role is gradual and progresses during the first few years of study; upperclassmen are significantly more likely to identify as engineers than first year students.³ For students, development of engineering identity is linked to the engineering experience through internships, co-ops, research etc.¹⁰ One would expect that adult students with prior engineering experience would likely develop identities as engineers more easily than their inexperienced counterparts.

Extensive work on the subject of identity development in the frame of role acquisition has been done by Thornton and Nardi. They proposed that in developing a strong attachment to an identity, one progresses through a series of four explicit stages in which a person moves from passive acceptance of role expectations to “actively engaging in and shaping them.” Identity development involves the progression through the anticipatory, formal, informal, and personal stages. During the anticipatory stage, individuals form incomplete, idealized conceptions of what a role entails is based off exposure to generalized sources, like the media. The person begins to

experience a role as an insider when they enter the formal stage and learn about the formalized, explicit expectations associated with a role. The next stage, the informal stage, is of equal importance. Here, individuals learn through interaction with peers how they are expected to act and behave without being expressly told by the system to do so. Finally, individuals enter the personal stage when they are able to internalize their role and link it with their existing identity, i.e. their personality, experiences, skills and values.¹¹ This frame can provide insight into the ways that adult engineering students build their sense of professional identity through multiple modes.

Successful development of an engineering identity is reflected by professional persistence. Work by Lichtenstein et al found that a minority percentage (42%) of seniors definitively planned on pursuing an engineering related career following graduation.¹² Undergraduate engineering programs must try to do better to foster engineering identity development so that professional persistence is improved and the workforce is provided a steady stream of capable degreed engineers from a variety of backgrounds.

Traditional Student Perceptions of Engineering Work

In order to understand engineering identity and persistence, we must examine what students think engineers do and are capable of. For this, we turn to Matusovich's work on undergraduate students' perceptions of engineering work. Traditionally aged students indicated that being an engineer involved being a problem solver, a good communicator, having passion for math and science along with with applying technical knowledge to find solutions to problems. Interestingly, it was found that there is a significant level of uncertainty in traditionally aged students about the engineering role; 3 out of 10 participants were unclear about what it means to be an engineer.¹³

By examining students' perceptions of what they will be expected to do as engineers, we can begin to understand why they engage in specific practices and how their professional identity develops as a result of such behaviors. Interpretation of engineering identity sets precedent for importance beliefs where students prioritize what skills and practices are most important for them to advance their professional identities.¹³ These priorities lead to the selection of activities that will allow them to develop said skills. Skill development instills self-efficacy which advances students' identities closer to the achievement of their perceived identities.

Methods

Our multi-institutional study was carried out with the goal of **identifying the differences and similarities in the development of engineering identity among adult engineering students at**

various different types of educational institutions. Data was collected from a community college (COM), a small private university (PRI), and a large public university (PUB). Semi-structured interviews were conducted with participants that were engineering undergraduate students age 25 and older with prior engineering work experience.

Context

COM is a community college and a federally designated Hispanic Serving Institution on the West Coast in the United States. During the 2011-2012 academic year, the College enrolled nearly 11,000 students, with Hispanic students comprising 35.5%, Caucasians 32.6%, Asians 8.1%, African Americans 3.9%, American Indian/Alaska Natives 0.3%, Filipinos 3.6%, Pacific Islanders 1.7%, multiracial 9.3%, other 4.9%. Of these students, 55% are aged 25 and older. Approximately 21% attend college full time. COM's mission is to ensure that students from diverse backgrounds achieve their educational goals by providing quality instruction. COM's Engineering Program is a transfer program that offers a comprehensive set of lower division engineering courses needed to transfer to any four year engineering program in any field of engineering. Exemplary support services exist at COM that provide students with access to math and physics preparation classes, peer tutoring, and offer fast-track math courses that allow engineering students to fulfil their math requirements quickly. Professional development is fostered by partnerships with industry to provide students access to mentorships, internships, field trips, resume and interviewing workshops, and scholarships. Students can regularly attend talks from STEM professionals to learn more about career paths as well as become exposed to innovations in STEM fields. Every year, about 30 students successfully complete the program and transfer to four year engineering programs all over the state, as well as out of state. COM's mission has a focus on providing the community with a learning-centered environment, supporting students from diverse backgrounds in their goals for transfer, career, technical, basic skills, and lifelong learning. The

PRI is a private institution located in the Northeastern United States with more than 4600 undergraduate students. Students over the age of 25 comprise 19% of students in the undergraduate engineering programs, which offer day as well as night classes. Of the students enrolled in engineering programs, 37% self report as White, 10% as Black or African American, and 5% respond as Hispanic. PRI offers professional development services that range from career workshops to personal advising as well as a career matching platform. An example of a structured professional development offering at PRI is a program that awards students a certificate upon successful completion of career planning workshops and opportunities. PRI has a career assessment system that matches students with potential careers based on their skills and interests, with support from advisors. Specifically in PRI's College of Engineering, engineering students' professional identity awareness is nurtured by professional student clubs, accessible

engineering labs and machine shop, and a developed alumni network. PRI's mission focuses on student-centered education in liberal arts and professional education, with an emphasis on experiential, collaborative, and discovery-based learning.

PUB is one of the nation's premier public universities located on the West Coast in the United States. As of fall 2012, PUB enrolled over 25,000 undergraduate students. Among undergraduates, 3% were enrolled part-time and 97% full-time. The average age of undergraduates is 21 years, with 7% aged 25 and older. A majority, 79%, of undergraduates are "in-state" from the state of the university, with 10% coming from countries other than the United States. Among domestic students, 44% identify as Asian/Pacific Islander, 32% White, 14% Hispanic, 4% African American/Black, and 1% American Indian/Alaskan Native. The entering class of new undergraduate students was composed of two thirds first-time freshmen and one third transfer students. PUB offers Bachelor's degrees in nine engineering disciplines. To assist students in their pursuit of engineering bachelor's degrees, PUB offers a variety of engineering student services. Advising is available to help students identify research opportunities, select relevant coursework, and successfully complete the graduation requirements for their degree. PUB also offers programs to introduce new freshmen and transfer students to the rigors of PUB Engineering through academic coursework and community building. Tutoring and other academic support services are available to help students strengthen their core engineering fundamentals as well as provide general tips on navigating college. PUB assists its engineering students with a selection of career development opportunities. Career advising is available to aid students with resume critique, cover letter revisions, and linking them with potential internship and job opportunities. Workshops are also put on by PUB to help students with general career topics. The PUB career center offers a specialized bi-monthly email filled with career opportunities and helps organize career fairs geared toward engineering job opportunities. PUB has a three-pronged mission of teaching at the undergraduate, graduate, and professional levels, conducting research to discover new knowledge, and providing service to the public.

Participants

Participants for our study were adult students (age 25 and older) with prior engineering work experience who were currently enrolled in an undergraduate engineering program.

Many of the typical characteristics of adult students were observed in the participant group: financial independence, having dependents, part-time college enrollment, full-time and part-time employment, along with delayed entrance to college. The non traditional adult student age minimum was set at 25 to avoid working with traditional students who decided to stay in school longer (i.e. super seniors). We limited our study to adult engineering students who had prior work experience to determine how this prior experience affected engineering identity development.

Institution	Total Number of Participants	Average Age	Age Range
PRI	5	36.4	26-54
COM	9	36.7	25-55
PUB	8	34.5	25-55

The average ages and age ranges of participants across institutions are comparable. Out of 23 total participants, only 3 female engineering undergraduates were interviewed, exclusively at PUB. Reporting race/ethnicity was optional for participants; 40% of participants at PRI, 0% of participants at COM, and 25% of participants at PUB self-identified as an underrepresented minority. Participants were made aware of the study via campus flyering and mass emails. After the participant contacted the principal investigator to indicate their willingness to participate, they were directed to complete a pre-qualifying survey to determine eligibility. In this survey they were asked about their age, degree program, and prior engineering-related work experience. Responses were evaluated and qualifying participants were contacted through email. Interviews were scheduled at the convenience of participants. Participants received \$25 for completion of the study.

Instruments

Semi-structured one hour interviews were conducted with participants at each separate institution by trained interviewers. Before the interview started, participants consented to being interviewed and were informed of the goals and motivations of the study along with their rights as participants. During the interview participants were asked questions regarding identity, motivation, and future plans. Audio recordings of the interviews were transcribed, encrypted for participants' confidentiality, and analyzed for themes. After the interview was completed participants were asked to complete an optional demographic survey that asked about employment status, gender, enrollment status, degree program, marital status, if they had dependents, etc. All participants completed this survey; the purpose of completing this survey was to gain a better understanding of how student demographic profiles vary amongst community colleges, large public universities and small private universities and to observe how responses differed as a result of demographic diversity.

Analysis

Thematic analysis was used to identify patterns in participant responses to the interview question, “What does it mean to you to be an engineer?” After these themes were identified, each transcript underwent a selective coding process to determine how commonly participants across institutions identified with different aspects of the engineering role. The purpose of this coding process was to develop a model of how students view engineering as a professional identity. We seek to understand what aspects of the professional engineering role these engineering student participants recognize and work to assimilate into their own identities.

Results

Demographic Analysis

Participants across institutions were all within the same age range (25-55) and had average ages in the mid 30's. Data for the employment status, course load, marital status and number of dependents are presented in Figures 1, 2, 3, and 4.

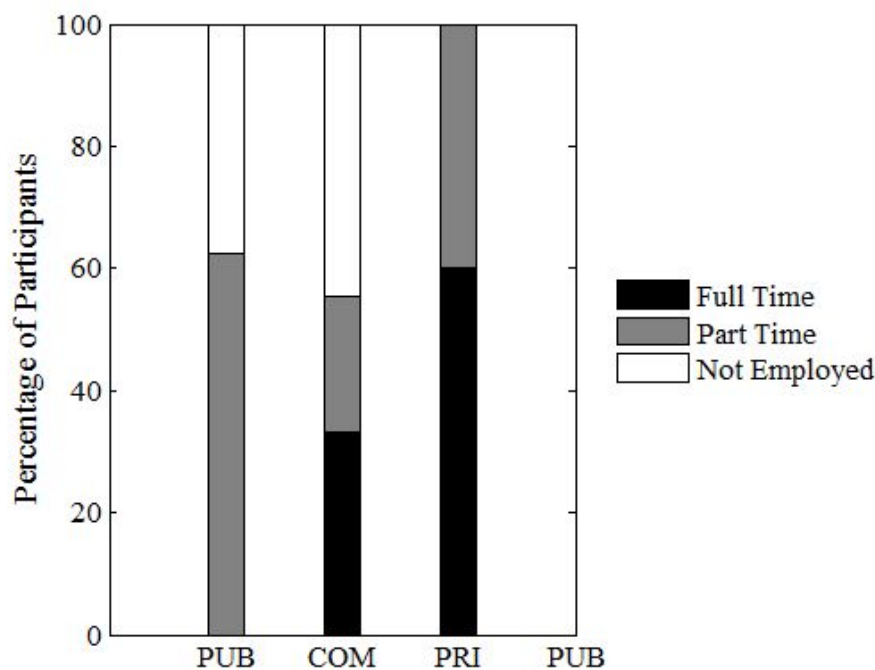


Figure 1: Participant employment status

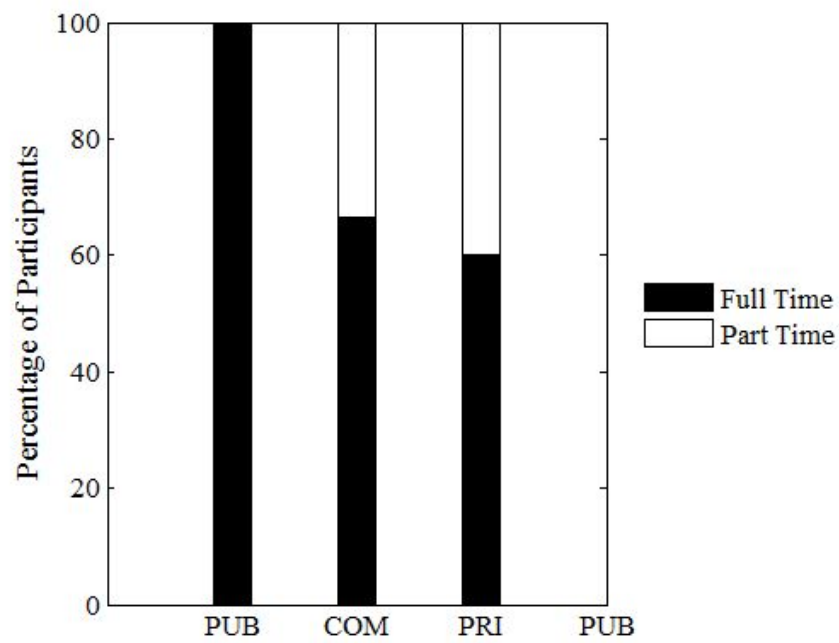


Figure 2: Participant course load

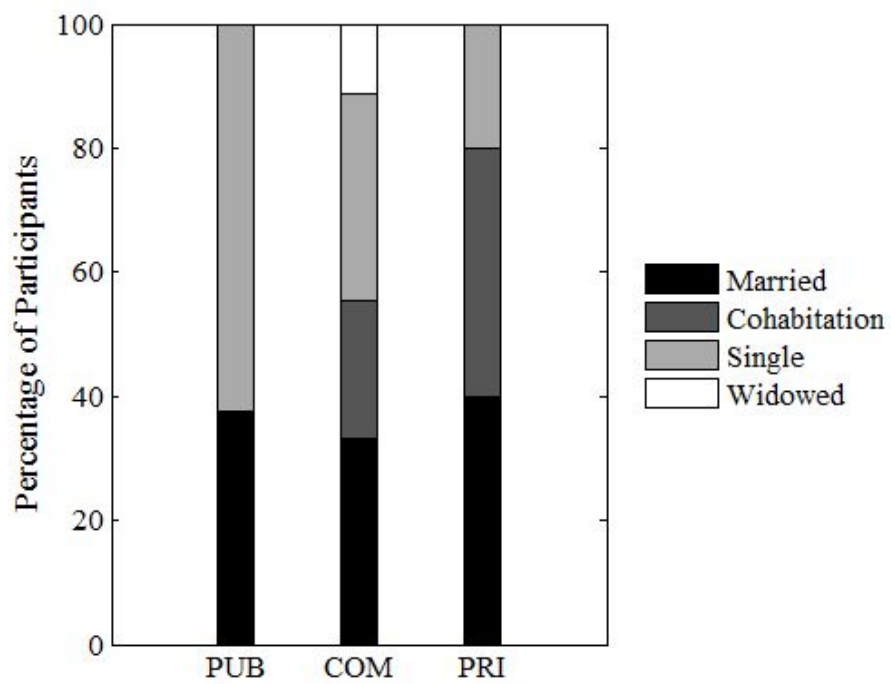


Figure 3: Participant marital status

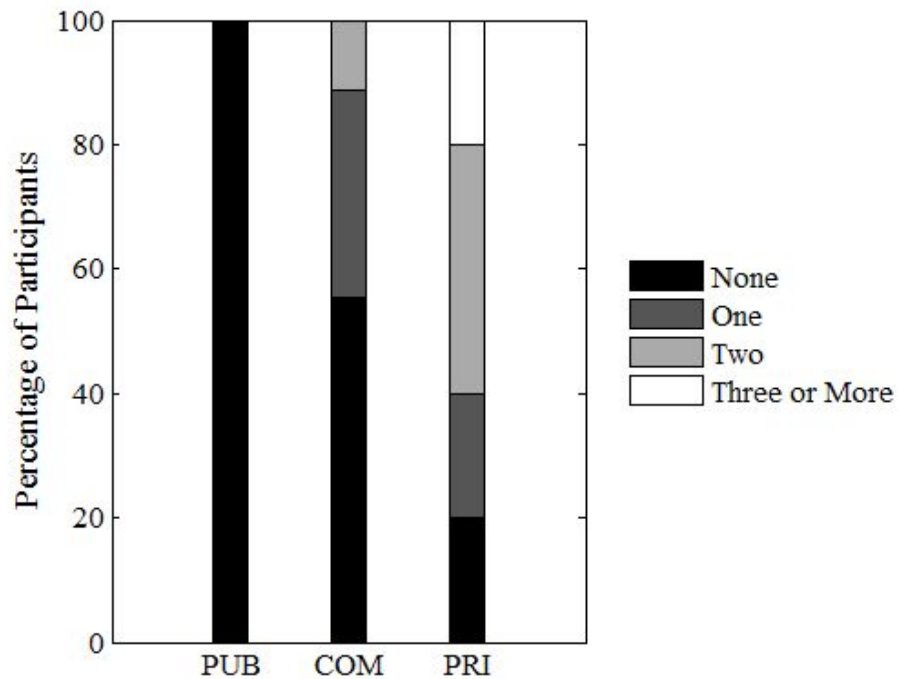


Figure 4: Participants' number of dependent children in care

Several differences can be seen across institutions. No PUB participants work full time, the majority of COM participants are employed to some capacity, and all PRI participants are employed. All PUB participants are full time students; both COM and PRI participants are split between going to school fulltime and part time but a higher portion of COM participants are full time students. The majority of PUB participants are single with no dependents. The majority of COM and PRI participants are married or in a cohabitative relationship/domestic partnership. The majority of PRI participants have one or more dependent, while slightly less than half of COM participants have one or more dependent.

Adult Student Perceptions of What It Means to be an Engineer

Participants were asked to share their thoughts on what it meant to be an engineer. Their responses are summarized below in Figure 6 .

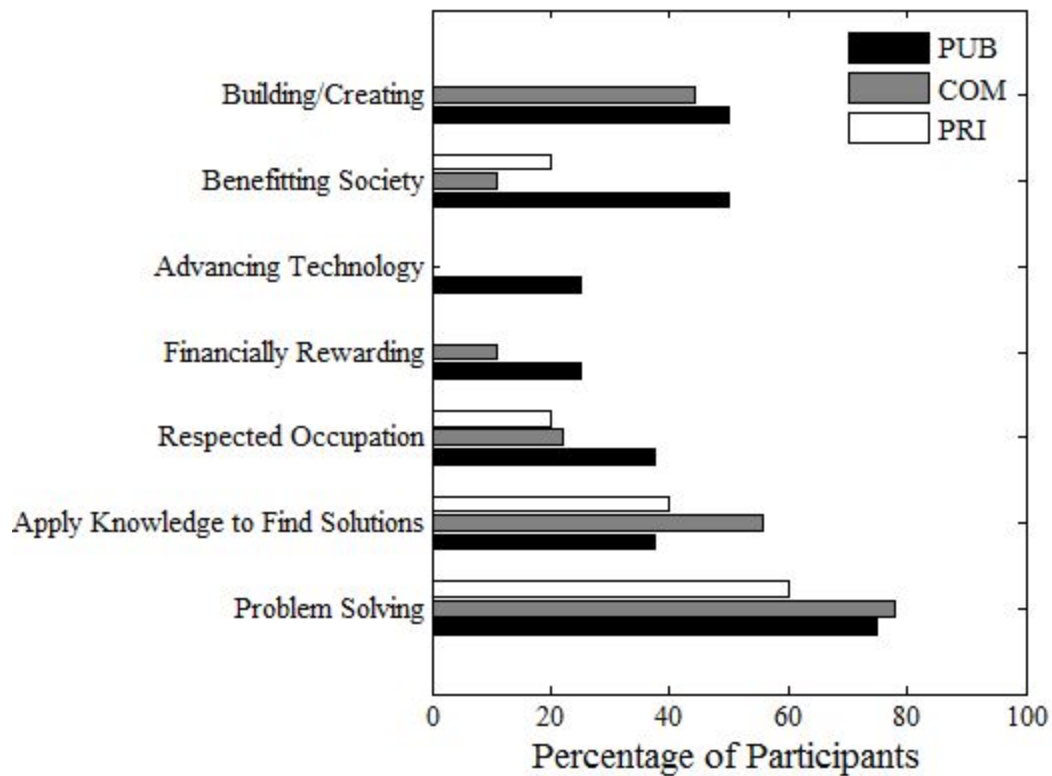


Figure 6: Responses to the question: What does it mean to you to be an engineer?

Fifty percent of PUB participants and 44% of COM participants associated building and creating with being an engineer while none of the PRI participants identified with this particular association. Benefitting society was associated with engineering by participants from all institutions (20% of PRI, 11% of COM, and 50% of PUB). Technological advancement was only associated with being an engineer by PUB participants (25% of all PUB participants). Being an engineer was seen as financially rewarding by PUB (25%) and COM (11%) participants with no PRI participants offering similar responses. Engineering was seen as a respectful occupation by participants across all institutions (20% of PRI, 22% of COM, and 38% of PUB participants). Participants from all three institutions also identified applying knowledge to find solutions to problems with the engineering occupations (40% of PRI, 56% of COM, and 38% of PUB participants). A majority of participants from all three institutions identified problem solving with engineering (60% of COM, 78% of COM, and 75% of PUB participants).

Discussion

Study Limitations

The data in this paper are drawn from part of a larger study to understand and respond to the identity, experience, and engineering process of adult engineering undergraduates. The data presented here have some limitations that may impact the generalizability of the results. Participants are drawn from only three institutions. While these institutions were chosen for diversity of institution type, location, and size, there are nonetheless only three. Furthermore, the results presented here include data collected from 5-9 participants at each institution. Data collection is ongoing for this and related components of the research program.

Demographics Comparison

Analysis of the the demographic surveys show important differences between students of different institutions. The majority of participants at PRI were married, had dependents, and were working either full time or part time. At COM, students were also likely to be working in some capacity, a large percentage were either married or in a cohabitative relationship. In contrast, PUB participants were all enrolled full time; none worked full time or had dependents. The differences between the types of students attending each institution can be partially explained by the types of support services available at each institution. COM participants noted the availability of evening classes which accommodated their work schedules, while PRI offered evening degree programs. Participants at PUB highlighted that such evening programs did not exist and that being a student at such a competitive university was overwhelmingly time consuming. This lack of accessibility and public awareness of adult student support programs at PUB has attracted a very specific adult student population who have limited responsibilities outside their academic obligations; the majority of PUB participants were single, had no children, and were not working full time.

While PUB participants had no parenting responsibilities, the same cannot be said about their peers at COM and PRI. Seven parents were interviewed, (3 at COM and 4 at PRI) none of which were female. Of the fathers interviewed, many indicated that being a provider for their family was a large motivator; this identity as a provider is in line with their pursuit of a financially stable career in the long term. It is important to note that none of the PRI or COM participants were female. Also note that the number of participants at each location was not uniform (5 at PRI, 8 at PUB, 9 at COM).

Institutional Comparison of Adult Student Perceptions of the Engineering Role

Participants were asked about what it means to them to be an engineer. They responded with their perceptions of the roles that engineers are expected to play in society. These include: problem solving, applying knowledge to find solutions, advancing technology, benefiting society, building/creating, and having a respectful and financially rewarding occupation.

Responses from our non-traditional aged students were consistent with the responses from Matusovich's traditional aged participants.¹³ All students indicated that being an engineer was closely linked to being a problem solver and having the "engineering state of mind" which encapsulates all of these traits. The main difference between our participants and the prior Matusovich study was that none of our adult participants communicated any level of uncertainty about what it means to be an engineer. This can be explained by the fact that all of our participants had prior engineering work experience and had clearer conceptions of what being an engineer means. Furthermore, adult participants must have a passion to pursue engineering in order to put themselves through the highly stressful process of balancing their established lives with the rigors of academic study. Traditional students, on the other hand, were less likely to have the same level of exposure coming straight out of high school, an environment that minimally exposed them to engineering work.

It is interesting to note that COM participants held similar expectations of the engineering profession as did those at PUB and PRI. One might expect that there would be a difference in this area because four year institutions have direct relationships with industrial companies that hire their graduates, and a structure in place with industrial information sessions, strong alumni networks, and industrial advisory panels. However, all participants in this study had some degree of prior engineering related work experience, allowing them to have an idea of the daily functions and roles of engineers. This can be further explained by the extensive support services offered at COM that specifically work towards creating an environment conducive to academic success and professional development. The engineering transfer program at COM offers students extensive academic support, including access to peer tutoring, math and physics preparation, and transfer assistance. It also allows them to gain an understanding of the professional roles engineers play through programs such as their speaker series in science and technology and access to professional mentorship programs and internships. An instrumental part of building a commitment to the engineering profession is through participation in and exposure to the activities of engineers. Student participation in research, co-ops, mentorship programs and the attendance of engineering functions give students a heightened awareness of the potential career paths they may take as well as a sense of what it fundamentally means to be an engineer. By learning and engaging in the formal and informal activities of engineers, students can strengthen their professional identities.¹¹

Conclusions and Future Study

The goal of this study was to investigate across multiple institutions how students conceptualize what it means to be an engineer and to what extent these conceptions differ as a result of different demographics. We hope to assist in developing methodology to improve recruitment

and retention of adult engineering students by strengthening the development of identification with engineering in this important demographic.

We found that, similar to traditional students, adult students view engineers as creative problem solvers. We did observe differences in the demographics of the study participants from each institution. Despite the contrasting academic and demographic backgrounds of participants, the responses were surprisingly homogenous. The top two responses indicated that participants expected engineers to be problem solvers and builders.

Because of the lack of diversity of the data sample, future work in this area should seek to understand adult women engineering undergraduates, especially mothers. The limited amount of women in the engineering workforce can potentially be supplemented by adult females who chose to come back to school. Better understanding of how to promote identity development in engineering programs will lead to increased retention of this demographic.

Recommendations

We can think broadly about recommendations to support the retention and professional identity development for adult engineering students at a range of institution types.

It is important at all stages and institution types to provide opportunities for engineering students to grow in their engineering identity, and their understanding of engineering work. This work suggests opportunities to enhance professional identity development at institutions of multiple types through industrial collaboration and mentorship, including such programs as industrial tours, formal mentoring programs, speaker series, and information sessions. Cooperative engineering work programs will allow engineering students to continue earning an income while studying, and at the same time develop important engineering skills.

Our data also suggest that an academic environment such as PUB is less likely to have inclusive participation of students who have competing responsibilities such as that of parent and employee. The authors recommend establishment of student-parent centers, student-parent policies around reduced course load or leaves of absence, student health insurance that allows for dependent coverage, and daycare centers for children of students to support engineering students with children.

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