Identity and Design Process in Adult, Non-traditional, Engineering Students: Phase I: Training for Extending Prior Studies

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Abstract

Adult students comprise a significant percentage of undergraduate learners, 10% within engineering programs. Whereas gender and ethnic diversity are commonly studied aspects, studies involving student age comprise a much smaller set of the available literature within the engineering education field. To increase the diversity and number of engineers in the workforce, it is critical that adult students be supported through degree completion.

Our work aims to create new pathways for non-traditional engineering students by examining the role of prior work experiences, identity, and expertise. The work supported by NSF REE collects and analyzes qualitative and quantitative data from non-traditional engineering undergraduate students at three diverse institutes of higher education: a large public university (University of California, Berkeley), a small private university (University of New Haven), and a community college (Cañada College). We foresee the data providing critical insights to enable engineering educators to be more effective, and making substantial contributions to our understanding of engineering identities and students' thinking processes. By filling gaps in current understanding of the identities, level of expertise, and experiences of these students, the study aims to improve persistence outcomes for engineering students and increase the number of qualified engineering graduates.

In an effort to leverage existing data, we have set out to replicate the work carried out by Atman/Cardella (2007) and Matusovich et al (2011) with a new study population comprised of undergraduate students aged 25 and over. The paper/poster will detail our efforts to train our research team of engineering and social science students in carrying out these experiments with a high degree of fidelity to the original studies. This work is being carried out at universities that do not have students focused on engineering education research; we describe the process by which we trained students to collect the data and actively participate in the research. Features of our training include: human subjects research training with a focus on the Belmont Report and its applications, training in semi-structured interviewing, analysis of the publications from the prior related work, practice data collection sessions, role-playing, training on thematic coding, and finally deployment in real data collection.

Motivation - Why Research on Adult Nontraditional Engineering Students

Engineers seek to find *solutions* to society's *problems*. The keystone to successfully attaining *solutions* may be said to be diversity - diversity of our lived experiences. We can claim that engineering, by its very nature, is dependent on teamwork and creativity of thought. Diversity increases the range and creativeness of possible *solutions* the team or individual can attain[(1)].

Whereas gender and ethnic diversity are commonly studied aspects, studies involving student age comprise a much smaller set of the available literature within the engineering education field. To increase the diversity and number of engineers in the workforce, it is critical that adult students be supported through degree completion.

Students age 25 and older represent a vital portion of the pool of students enrolled in US colleges. In 2007, 37.6% of all students (any major) enrolled in 4-year institutions, and 40.3% of all students enrolled in 2-year institutions were age 25 and older[(2)], yet non-traditional students have received little attention in engineering education research. When examining adult students in engineering, the Multiple-Institution Database for Investigating Engineering Longitudinal Development research shows that nontraditional students are 10% of the undergraduate engineering population in a large sample of eleven 4-year institutions in the United States from 1988 to 2002. This report finds that nontraditional adult students have a reduced graduation rate compared to traditional students, suggesting that they experience group-specific barriers.[(3)] Our research work aims to enable faculty, administration, students, and higher education policy professionals in diversifying the pathways through STEM careers by contributing to the body of knowledge about non-traditional students.

For our work, an adult student is one who is 25 years or older, completing a bachelor of science in engineering degree. We define the traditional student as one who enrolls in a program directly after completing their high school years. Some traditional engineering students may take more than the 4 or 5 years typical for degree completion; limiting the age at 25 and over excludes from our work any traditional student who may have taken up to 6 years to complete their degree requirements.

What we find in the literature

The question of professional identity among engineering students has been a topic of significant study recently in the United States and abroad. This work is motivated by the efforts to improve persistence in engineering programs, and it is generally situated within the theoretical framework of multiple identities.

Students experience learning as a complex system of interactions between institutional, social, and personal factors, and professional identity can be considered an "emergent property of the complex learning environment system".[(4)] A person's identity is not a static or one-dimensional property, but rather is situationally dependent, and is continually constructed. Gee's work on identities recognizes that all people have multiple identities related to their behavior within society.[(5)] These roles can gain their meaning from nature, institutions, personal interactions, or belonging to a group. Individuals have variable levels of commitment to particular roles or identities, and value most strongly those roles which express their true selves. Identity is therefore an important

construct when considering the design of educational and occupational settings. We are examining engineering identity as a specific professional identity.

Research work with freshmen engineering undergraduates identifies differences among freshmen engineering students who continue to study engineering compared to those who transfer to other majors.[6, 7] While both groups of students reported that they did not "feel like engineers" yet, lacking clear or accurate ideas of what engineers do, and both groups felt academically prepared to study engineering, there are some meaningful differences in the experiences and perceptions of these groups. Freshmen persisting in engineering programs were more likely to have a connection with engineering peers and faculty, to be intrinsically motivated to study engineering and proactively engage with engineering clubs, and had more knowledge and exposure to engineering prior to entering college (such as through engineering camps, high school engineering classes, or personal relationships with engineers).

While these studies demonstrate the importance of exposure to and experience with engineering prior to entering college, it is important to enhance engineering identity among students after they reach college engineering programs. Matusovich *et al*[8] compare the professional identity development of engineering students and military academy students--as a model of successful positive professional identity development--to determine which factors are important in identity development. Interviews with 20 students across all four years of academic study revealed that overall there was a higher level of professional identity among military academy students compared to public and private university students, and that military cadets more readily provided examples of identity development, such as basic training, ROTC, and reflection. The authors concluded that providing opportunities for engineering students to work together on challenging tasks is important to develop engineering identity.

Recently, Meyers *et al*[9] used stage theory as a framework for modeling engineering identity development among engineering students. The study consists of an electronic survey asking engineering students in a medium-sized private university if they consider themselves as engineers, and asking them to identify factors necessary to be considered as an engineer. The study shows that sophomores, juniors and seniors were more likely to identify themselves as engineers than freshmen. Male students were also more likely to identify themselves as engineers than female students. Furthermore, students with future career plans to continue in an engineering related field after graduation were more likely to self-identify as an engineer. The most commonly identified factors as being necessary to be considered an engineer were intangible factors such as being able to make competent design decisions, being able to work with others by sharing ideas, accepting responsibility for the consequences of actions, and speaking/communicating using accurate technical terminology.

We can consider this research in the context of non-traditional engineering students with prior engineering-related work experience. We expect that the prior exposure to the engineering profession has allowed these students to develop a strong identity as engineers. Prior research by Ciston and Carnasciali [10] shows that non-traditional students have high levels of motivation, and we propose that the expectancy-value theory of achievement motivation developed by Eccles and Wigfield [11] may be extended to engineering students.

Training the Trainer

Semi-Structured interviews

In a semi-structured interview, a set of open-ended questions are prepared ahead of time and a one-on-one formal interview is carried out. Semi-structured interviews provide a means of collecting reliable, comparable qualitative data and are particularly useful tools for when the data will be collected by various interviewers,[12] provided a careful protocol is followed. The interview follows the set of pre-planned questions yet allows the interviewer to deviate from the proposed guide based on the discussion and what the participant brings up; if not enough is said about a point of interest follow-up questions are at hand which may trigger further discussion. The interviewer must be cautious to probe for further info without leading or influencing to a particular response; this requires some level of training and practice. The nature of the semi-structured interview requires the interviewer to listen carefully and to allow the participant freedom of expression (i.e. not limiting length of what they say). As such, the interviews are often audio recorded and later transcribed to enable data acquisition. Once transcribed, thematic coding and analysis of the narrative takes place. Multiple researchers code each transcript independently. Thematic analysis is carried out based on the grounded theory method of qualitative analysis in which themes are inductively arrived at based on what the data provides. The researchers then come together to discuss and decide on the basic themes and categories of statements which were identified. The researchers then go back through the transcripts analyzing based on the themes and categories agreed upon. The data is compiled allowing for conclusions and recommendations to be drawn from the results.

Semi-structured interviews and coding of open-ended responses are commonly used evaluation tools in various fields, including in engineering as a tool for determining user needs and project/product requirements; however, few engineers receive formal training in the methodology. The authors had mixed backgrounds and experience in this work. Carnasciali received formal training as a graduate student working as a student assistant to engineering education and assessment researchers. The training was carried out in multiple stages; first by reading about the methodology; second, by observing practitioners; third, by role playing and obtaining constructive feedback; and lastly, by doing. Expertise were further developed as a postdoctoral fellow at the Center for Teaching and Learning at Georgia Tech where much of the work involved data collection and analysis for program evaluation purposes. Presently,

Carnasciali teaches an Introduction to System Engineering course which emphasizes customer awareness and development of user and system requirements, and thus provides a means for engineering students to become exposed to the formal practice of data collection via focus groups and semi-structured interviews. Ciston, on the other hand, first assisted in engineering education data collection as a graduate student volunteer. Her training consisted of reading literature work, then specific training and role-playing for an experimental protocol on observing engineering group dynamics, and finally collecting study data. Early in her faculty career, she trained with Mike Hollis, who has a background in anthropology and engineering education, in qualitative research methods including the use of grounded theory. She has been applying these methodologies to the study of adult students since 2010, and has been conducting student focus groups aimed at curriculum assessment since 2010.

Think-aloud protocols

In a think-aloud protocol, a study participant is given a particular task to tackle and asked to say aloud what they are thinking, looking at, doing, about to do, etc. The observer is then able to follow the process of accomplishing the task rather than just the finished task itself. Founded on psychology research, in engineering the method is often used for studying process tracing, decision making, and for product design and development. It is critical to the method that every effort be made to minimize disruptions in the cognitive process [13], as such, the observer does not interject or question the way it is done in an interview. The think-aloud exercise is recorded (often both audio and video) so that the researchers may refer back to what the participant did or how they acted.

Though the researchers were familiar with the methodology of the think-aloud protocol, neither had actually conducted one for data collection. Dr. Monica Cardella, an expert in learning design protocols, was contracted to train the PIs and advise on conducting the design interviews. Dr. Cardella is an Associate Professor of Engineering Education at Purdue University and has been conducting research on design thinking and engineering design education nearly 15 years. As part of her experience [14], she coordinated the process of administering a think-aloud problem (used in a verbal protocol analysis studies of design processes) for the collection of data from expert engineers. This involved collecting all of the equipment and materials for the study, administering the playground task to research participants, collecting video, audio, and field note data as participants completed the task, and documenting the data collection. She has also trained other researchers in the process of administering the task to other populations and has trained multiple graduate research students to administer the same task being used by the current authors.

For the training, Cardella administered the think-aloud protocol to Ciston who played the role of the research study participant; Carnasciali observed the whole session. The setup and supplies were the same as what needs to be used to conduct a data collection session. The training was

video recorded to assist in training and discussion. Post the interview session, the researchers and Cardella discussed the procedure including logistics of camera position, items to have at hand, and strategies for reminding the participant to speak-aloud all they were thinking and doing. This was then followed by a review of the video - this time focusing on how the data would be analyzed. At the end of the training day, Cardella provided each of the researchers a memory stick with all the documents needed to conduct the design study, as well as a copy of the day's training interview.

Training the Students

The training of the students took much the same methodology as how the authors were trained. The students involved in our work at the University of New Haven have been students enrolled in a master's degree in Psychology. These students tended to be familiar with collecting data from human subjects, carrying out interviews and were generally comfortable with literature on motivation, stressors, and identity. As part of their degree program, they would receive further training on topics such as research methods, statistical analysis, and social/industrial behaviors to name a couple. In general, the first task assigned to the students was to complete training for the ethical collection of human subject data. This involved completing a series of online modules and short assessments as required by our campus. The students were then provided a series of journal articles related to the research. Much like the training conducted for the authors regarding think-aloud protocol, the students role-played being interviewed and then debriefed. The students were then asked to review and practice conducting the interview until they felt comfortable with the questions. Emphasis was placed on the follow up questions and allowing the conversation to go where it *wanted* based on the participant's comments/responses. The students were also provided journal articles referring to prior data collected. They were then to conduct a *real practice* interview - for this, the PI generally found another graduate student assistant or an undergrad assistant - this data would not be used except for training purposes. The PI and graduate student met to discuss the interview and review the audio recording. In some cases, the student was asked to conduct additional *real practice* interviews. The PI determined when the student was ready to commence actual data collection interviews. Between interviews, the audio recordings were transcribed; several of them were collected before data was analyzed.

Students involved in the research at the UC Berkeley campus have been undergraduate students studying an engineering discipline. These students also began their training with an online certificate program offered through CITI for ethical human subjects research. The students each read the book *Interviewing as Qualitative Research* by Irving Seidman, along with publications on prior work. Student then each took turns completing multiple practice interviews and doing role-playing before beginning data collection in earnest.

Reflections on the training

Research Assistants

Christina Foy: In reflecting back on my research assistantship, I gained a wealth of knowledge in data analysis, interviewing human subjects, and survey research. Specifically, what appealed to me was the opportunity to sharpen my analytical knowledge and skills. As a disability analyst for New York State, I have used these acquired skills to propel me to high level of competency and accuracy.

Emi Okada: I have great interest in learning what challenges and motivation adult students experienced while they pursue bachelor's degree in engineering. In order to have a better understanding of their academic and social background, I read journals about challenges and motivations of adult students in community colleges and 4-year Universities, and challenges and motivation among all engineering students. During the literature review, I enhanced my critical reading and thinking skills, which benefits me to analyze the deeper meaning behinds words in the interview transcript. My listening skills also got sharpened while conducting the interviews; I learned and practiced the rules of thumb of interviewing: listen more, talk less and follow up with real questions. I appreciate this opportunity to enrich my critical thinking and listening skills, which would help me perform better in research, academic and career field.

Pedro Sung Hoe Kim: Looking back on my experience as a research assistant working under Ciston, I can only be thankful for the structured approach in preparing me for the job duties. First, the CITI (Collaborative Institutional Training Initiative) training program thoroughly introduced me to Human Subjects Research and the precautions needed to protect the participants from any harm, along with IRB (Institutional Review Board) step-by-step procedures to be granted research approval. Ciston also expected me to have studied Irving Seidman's *Interviewing as Qualitative Research* before interacting with any participants. I felt well-prepared conducting the practice sessions, and that confidence translated into more structured and organized field-interviews with actual participants. Overall, I came to appreciate the rationale behind designing research studies and meeting expectations of professionalism, team-work and deliverance. I developed my critical-thinking and leadership skills and nurtured my passion for education from interacting with students from a wide range of backgrounds. While learning more about the factors that lead to more persistent non-traditional engineering students, I came to understand the impact that prior engineering-related work experience has upon students and their development as engineers that can provide an invaluable service to society.

Audrianna Rodriguez: The position enables me to apply statistical/analytical skills obtained from class to the research project. This is important in my educational training because it provides rich

hands on experience in the development and application of my psychology training. The opportunity will be crucial for my next endeavors and I am glad to be a part of the team!

Principal Investigators

The PIs are at drastically different universities and yet face one common hurdle - the struggle to obtain qualified research assistants. Whereas PI Carnasciali does have access to graduate students to assist in the work, the work is not seen to be 'in the student's major'. Reaching qualified students to apply for the research position is hard - from difficulty in getting them to know about the open position, to being in a different building, to not having those students in classes from which to recruit. Getting the potential students to bypass the fact that the research position is in *engineering* also takes some convincing. Lastly, is the issue that the students see this as 'hourly work' - something they do on the side, which does not contribute to their degree requirements. Figuring out a way to partner with faculty from psychology and/or education may lead to better partnerships and more acceptance from the students and their faculty.

PI Ciston, on the other hand, works primarily with undergraduate students. There is a strong culture of undergraduate students engaging in research work for professional development, course credit, or pay within the department and college. Scheduling meeting times with students from diverse degree programs can be a challenge, and finding appropriate spaces on campus for conducting interviews and design studies is challenging. We have found that reserving student work space in the engineering library is a helpful strategy.

The feedback received from the reviewers of our early work pointed to concerns regarding the massive job of collecting sufficient data to be meaningful; they urged us to leverage existing data and tools. We selected the specific studies because of the clarity of the procedure in their published work and their willingness to be available to train and mentor us. Needless to say, that was not the case with every study we reviewed. Often little things are not mentioned that could make a big difference - for instance, what prompts or follow up questions does the interviewer have at hand; give your study participant a break but stop the clock; or go ahead and use video/web conferencing to conduct your interviews. The validity of our work will depend on our ability to replicate their work accurately. We hope to have captured the little nuances that made their work - their work. We look forward to next year when we can present data collected and analyzed and begin the comparison.

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