Board 202: A Preliminary Analysis of Identity Development in the Figured Worlds of High-Achieving, Low-Income Engineering Students

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Background

The ongoing lack of diversity in engineering fields has been described as both: a) a critical issue with a detrimental impact on the United States' ability to compete with global innovation [1] and b) a systemic issue that excludes certain groups of people from opportunities for economic mobility and job security [2]. Historically excluded groups, including women, Black/African Americans, Latino/Hispanic Americans, and economically disadvantaged individuals, continue to be in the minority in engineering [3]. Through years of research on historically excluded groups, researchers have asserted the importance of developing an engineering identity in determining later success in engineering [4], [5], [6]. With only 8% of all engineering students entering higher education from low-income backgrounds [7], [8], these students often face significant barriers to their success [1], [9], yet there has been very little attention given to them in the research historically. Our study seeks to address the gap related to this population and support the developing understanding of how high achieving, low-income students form engineering identities, as well as the intersectionality and salience of their other socio-cultural identities.

Study Purpose

The concept of figured worlds [10] guided our research questions and methodology. According to Holland and colleagues [10], figured worlds are "socially and culturally constructed realms of interpretation in which particular actors are recognized, significance is assigned to certain acts, and certain outcomes are valued over others" (p. 52). Figured worlds can also be described as "imagined communities" influencing identity, agency, and possibility. As actors continue to engage in the figured world, their lives, and the activities that they participate in begin to symbolize their identity within a particular figured world [10]. Wortham [11] suggested that thriving in a figured world requires participants to engage in appropriate behaviors to develop identities and obtain the requisite social capital. Thus, it is valuable to develop an understanding of participant perceptions of both the figured world of engineering and the requisite activities needed to thrive in it.

Using this theoretical framework as our foundation [10], we sought to explore what factors shaped the formation of an engineering identity for high achieving, low income college students participating in an engineering scholarship program. Specifically, our research questions were: (1) What factors shape the formation of engineering identity for high achieving, low income students participating in an engineering scholarship program? and (2) How salient are other social identities in the formation of their engineering identity?

Methods

A constructivist grounded theory (CGT) design framed the coding and analytic process for the preliminary stage of this study [12]. Throughout the analytic process, our research team, which consisted of one principal investigator, one faculty member from the University of Cincinnati, and two doctoral candidates, engaged in multiple iterations of constant comparison

of the data, which is often associated with a constructivist grounded theory method [12]. We also examined our positionalities and challenged our potential bias throughout the analytic process. We selected this particular approach to grounded theory (GT) because it was important for us to acknowledge that the students' realities and perceptions are socially constructed and given the multiple positionalities of our team, both sets of experiences would influence the co-construction of the students' experiences [13]. By extension, our collective experience within the college of engineering and the SSTEM program would shape our interpretations of the data [13].

Furthermore, the constructivist approach to grounded theory aligns with a relativist ontology and subjective epistemology which require the researchers to ensure transparency in the analytic process through reflective engagement [14]. The constructivist method of GT represents a call to action and can involve approaches such as using the analysis as a foundation for making specific changes in the lives and experiences of the program participants [15]. Thus, a major goal for this study is to utilize the results to improve the academic, social, cultural, and personal experiences of high achieving, low income engineering students who have historically remained underrepresented in engineering programs. The next stage of our study will involve an analysis of all transcripts and focus group data, along with construction of a full theoretical model.

Participants & Instrument

The participants were purposely recruited because they are National Science Foundation (NSF) STEM scholarship (SSTEM) recipients [16]. However, they volunteered to participate in the research with an understanding that it would bear no weight in evaluations for their continued scholarship funding each year. NSF SSTEM-sponsored program activities that could shape the figured world of participants included intentional mentoring, cohort-based seminars, practical experience in design courses, and connecting students to internships and co-ops. The program model is patterned after successful SSTEM programs at other institutions, including the High Achievers Scholarship Program in Computer Science and Mathematics at Appalachian State University [17], as well as an NSF STEP program at the University of Wisconsin at Milwaukee [18]. The purpose of the program's cohort experience is to provide the participants with shared experiences that can support the transition through their engineering programs and promote the development of engineering identities.

Seminars provided participants with cohort building activities, professional networking opportunities, and knowledge that builds their navigational capital, such as tips for applying to study abroad and graduate school. Furthermore, engineering program advisors invited participants to join Engage ME, a college of engineering program designed to successfully recruit, retain and graduate multicultural students with degrees in engineering by connecting them with diverse mentors and social networking opportunities. Throughout the year, participants were invited to engage as a cohort with professional engineers, visit internship sites, and observe field studies of active engineering projects in the community. The year concluded with a highly attended networking dinner, featuring speed mentoring, where participants spoke with multiple different potential mentors throughout the evening; at the end of that evening, participants engaged in cultural events in the city as a group.

Programming and other opportunities were advertised to participants through a variety of channels, including emails from their engineering advisors and multiple channels of correspondence from the project's associated graduate research assistant. An electronic calendar was used to send out event invites which participants could respond to, and the graduate research assistant would follow up with reminders close to the event by email. While there was higher, consistent attendance at Fall events compared to Spring events, this could be due to shifts in the nature, structure, and scheduling of seminar events. Based on student requests, in the Spring semester, we aimed to leave campus and tour active engineering projects as a group; however, this presented challenges with accommodating both the schedules of our site hosts and the student schedules. The associated program advisors and graduate research assistant (GRA) relationships with the participants, built through regular communication, casual conversations at SSTEM events, and active support for participant networking with professional engineers, may have influenced participant attendance at events when their schedules allowed.

The preliminary results presented in this report were part of a larger study that is investigating the longitudinal development of this sample throughout the four-year duration of their engineering scholarships at a large urban public research university in the southeast. The study sample (N = 15) included five women and ten men who were undergraduate students in civil engineering, computer engineering, electrical engineering, electrical engineering technology, mechanical engineering, and mechanical engineering technology. Although we are still in the initial stages of coding, we intend to report our findings of the full study sample. For the purposes of this preliminary study, we used a sub-sample of the participants (n = 5). The sub-sample of participants included two women and three men who were undergraduate students, ranging from sophomore to senior, in computer engineering, electrical engineering, electrical engineering technology, and mechanical engineering. Participant demographics including college major and self-identified race are shown in Table 1. Semi-structured interviews were conducted in the fall semester with the entire cohort of fifteen recipients of an NSF SSTEM engineering academic scholarship. Each interview lasted for one hour. The interview protocol consisted of questions pertaining to the participants' pre-college experiences, current academic, social, and emotional experiences. The sub-sample (n = 5) is denoted within Table 1.

Table 1. *Participant Demographics*

Participant Number	Major	Race	Gender
1019	Civil Engineering	Hispanic/Black/White	Male
*1012	Civil Engineering	White	Female
1018	Civil Engineering	White	Male
1022	Computer Engineering	Not disclosed	Female
1017	Electrical Engineering	Black	Female
1011	Electrical Engineering	Not disclosed	Male

1023	Electrical Engineering	Not disclosed	Male
*1016	Electrical Engineering	Not disclosed	Male
*1015	Electrical Engineering Technology	Black	Female
*1013	Mechanical Engineering	Hispanic and White	Male
1021	Mechanical Engineering	White	Male
*1014	Mechanical Engineering	Black	Male
1026	Mechanical Engineering	White	Male
1025	Mechanical Engineering Technology	Hispanic	Male
1024	University College	Black	Female

**Participant included in the sub-sample of preliminary results*

Data Analysis

According to Charmaz [14], CGT is an inductive approach to theory building. The methodological foundation of CGT rests upon transparency, reflexivity, and positionality [15]. Data analysis occurs in two phases, initial and focused coding. The purpose of the initial coding process is to examine and label sections of the data with emergent codes. Throughout the first phase of coding, the team remained open to new codes, and kept a record of new codes. Subsequently, the research team created the initial codebook. The current study represents the second phase of analysis, focused coding. The emphasis for this phase is to engage in a process of focused coding which involves the identification of the most salient codes and themes in the dataset. We defined salient codes as those with the highest frequencies.

Since we are still in a preliminary phase of building our theory, the purpose of our initial data analysis was to identify high frequency codes, those that were applied to the interview transcripts most often. Focusing on the high frequency codes will help the team decide whether we need to re-evaluate specific codes and texts and engage in an additional round of comparative analysis. We used Atlas.ti software to aid our efforts to establish the trustworthiness of our coding and thematic development.

Results

Results of our analysis revealed important details that will help our team determine if the grounded theory method establishes a sound initial foundation for the broader theory development. Codes with the highest frequencies provided insight into which codes and their respective themes were most salient in the participants' descriptions and interpretations of their experiences. Figure 1 below shows the saturation of the five highest frequency codes and Table 2 provides the definitions for how we coded each of those frequencies.

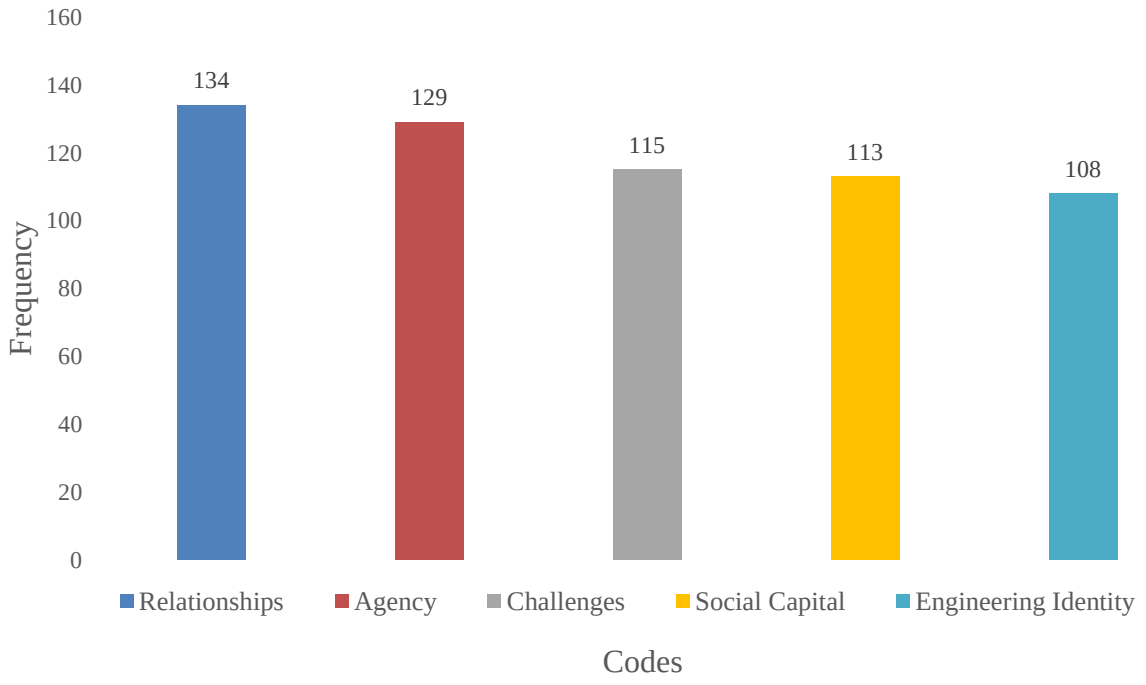

Figure 1. *High Frequency Codes (Preliminary Analysis)*

Table 2. *High Frequency Code Definitions*

High Frequency Code	Definition
Relationships	Students describe their personal, *not academic*, relationships (i.e., friends, peers, family, etc.)
Agency	Students describe (a) self-reflection and(b) intentional action and interaction with their academic environment(s) to exert some influence on their educational trajectories or future professions. Note: Agency is temporal, social, cultural, and contextual [19].
Challenges	Any reference to or description of academic or social challenges.
Social Capital	Social capital is "...an accumulation of resources, networks, and relationships that provide students access; build on their abilities, and lead to their academic success [20].
Engineering Identity	Students describe or refer to their ability to see themselves as current or future engineering professionals.

We also ran an analysis to measure the rate of agreement and disagreement between three coders. This initial analysis shows a 31% agreement between the coders. Since we are in the early phase of analysis and the sub-sample included only five interviews, the research team anticipates that the percentage of agreement will increase when all interviews are coded and

included in the final analysis. Results from this study have the potential to increase understanding of how to best support the success of high achieving, low income college students in engineering programs, including the implementation of targeted interventions and supports, as well as shed further light on the skills they use to overcome systemic barriers.

Discussion

Because we are still in the preliminary phase of constructing our grounded theory, the results shared thus far revealed high frequency codes of a sub-sample of five participants. However, we believe these precursory results can inform the remainder of our coding process, situate ourselves in a strong grounded theory, and illuminate potential implications for the engineering profession. Emerging themes from our preliminary data analysis reveal the importance of relationships, both professional and personal, especially as it relates to the participants' construction of their engineering identity and how they navigated academic challenges.

Agency and social capital were also dominant preliminary themes. For engineering students, being purposeful about how and with whom they interacted within their academic setting helped to solidify their engineering identity and impact their future career decisions. It is also evident that the relationships students developed and the accessibility of resources served as protective factors against several of the challenges they experienced. Students who were able to form study groups, seek out tutoring, and/or receive mentorship from engineering professionals felt supported and grounded in their engineering identity.

Implications

The preliminary results suggest the importance of relationships, social capital, and agency on the development of students' engineering identity. The results also indicate how students navigate academic and personal challenges based on the amount of social capital wealth they possess. For future implications, engineering programs can begin to evaluate how they provide mentoring and networking opportunities to their students, especially those from low income backgrounds to create or strengthen their engineering identity. Additionally, engineering programs can assess their students' perceived level of support, both professional and personal, and evaluate how peer relationships have either helped or hindered their success. By assessing students' needs regarding relationships and social capital, engineering programs can be intentional about providing services that increase students' social capital wealth. We are excited to continue to analyze the remaining data and develop a sound grounded theory approach with the hope to increase others' understanding of how to best support the success of high achieving, low income college students in engineering programs.

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