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EAGER: Broadening Participation of First-Generation College Student

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EAGER: Broadening Participation of First-Generation College Students in Engineering – Backgrounds, Experiences and Strategies for Success

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EAGER: Broadening Participation of First-Generation College Students in Engineering: Backgrounds, Experiences, and Strategies for Success- An Executive Summary

Introduction

When researchers have turned their attention to first-generation college students, it has been to understand why they appear to be losing ground in comparison with their peers. Multiple studies suggest that first-generation college students attend less selective institutions, have lower GPAs and drop out at higher rates when compared with continuing-generation college students (e.g. [1], [2]). When examining engineering students from high schools that were economically privileged, these students were more likely to enter colleges and universities with large numbers of engineering undergraduate programs [3]. Additionally, access to engineering bachelor's degrees was found to be more constrained for low-income students of color than for their white peers [4]. Despite these barriers, first-generation college and low-income students still enter engineering programs, although national reports have not determined the percentage of these students in engineering.

The question of how engineering schools can best support first-generation college students remains open, though many programs are based on a deficiency lens and seek to mold these students to become more like their privileged peers. The first-generation college students, from working-class family backgrounds, we came to know through our own research and teaching spoke about how their experiences and the experiences of their community as people who worked with their hands for a living were devalued and even erased from the engineering curriculum and teaching practices [5]. Thus, in our first ethnographic research project with first-generation college students in engineering, we challenged the dominant deficiency lens by investigating the unique strengths these students brought with them to engineering by virtue of those very backgrounds. Many of the low-income, first-generation college students were effective engineers in community development projects because they could design in the midst of scarcity, empathize with poor communities, and recognize the sociotechnical nature of engineering. Others worked in construction projects and developed an ethic of caring for workers, not for fear of liability, but empathizing with those coming from similar socio-economic backgrounds [6]. We also found that, although with difficulties, they could use their funds of knowledge to establish a sense of belonging in engineering, which is essential for their retention, successful graduation, and transition into the engineering workforce [5]. Drawing from sociological and educational research, we argued that these traits are valuable *funds of knowledge* – family and cultural knowledge developed by growing up in poor and/or working households – that make them effective engineers.

In this project, we expand on this asset-based perspective to investigate – quantitatively and at a larger scale – the connections between first-generation college students' home and work experiences and their current engineering degree trajectory.

Project Overview

The EAGER project Broadening Participation of First-Generation College Students in Engineering: Backgrounds, Experiences, and Strategies for Success (NSF #1734044) proposes to understand how first-generation college students' funds of knowledge can be leveraged in their

engineering work and the factors that contribute to their success in engineering through the following research questions,

1) Which funds of knowledge contribute to first-generation college students' future success in engineering?
2) Do first-generation college students' funds of knowledge support their beliefs about performing well in engineering and understanding engineering content?
3) What are the differences between funds of knowledge of first-generation college students and continuing-generation college students?
4) What are the differences in funds of knowledge of students who live at the intersection of multiple demographic variables (i.e., first-generation college students, low-income, racial/ethnic minorities, and/or women)?

In this project, we define success not through performance metrics, such as GPA or grades in engineering courses, but rather through students' beliefs about their confidence in completing their engineering degree, obtaining the knowledge required to be successful in their career, and certainty of attaining their desired career path. Prior work has utilized metrics such as High School GPA and SAT math scores to understand graduation rates (e.g., [7], [8]). We move away from using these metrics of success for three reasons: 1) first-generation college students tend to have more diverse pathways than continuing-generation college students, that is, a high percentage may have passed through community college before transferring to a four-year institution [9], [10]; 2) we sought to capture students *beliefs* about their abilities to succeed in engineering; and 3) many of the first-generation college students in our original ethnographic study refused to define their success by their GPA.

This executive summary provides an overview of the funds of knowledge constructs used in the survey and a summary of some of the survey questions, including engineering identity, engineering agency, belongingness, and certainty of career trajectory.

Developing a Survey to Recognize First-Generation College Students Funds of Knowledge

We drew from interview data of 14 upper-level low-income, first-generation college students in engineering and 12 first-year engineering students (including both first- and continuing-generation college students) to help identify funds of knowledge themes from students themselves. We classified these into six broad themes to capture aspects of these students' funds of knowledge: community networks, connecting experiences, tinkering knowledge, perspective taking, reading people, and mediational skills. The research team went through several iterations in order to obtain agreement with the phrasing of each statement for the survey. External support from graduate students in engineering education was sought to provide feedback on the survey items. After an agreement was reached and all feedback was taken into consideration, the survey was pilot tested to students at two universities in the United States south and mountain regions. Convenience sampling was used in the initial testing and validation of the funds of knowledge survey constructs. That is, a pilot survey was completed by 186 students varying from first-year engineering students to fourth-year or higher, of which 32 were first-generation college students, 154 were continuing-generation college students, with 1 student not reporting parental level of education. To date, exploratory factor analysis has been conducted to determine the underlying factor structure of each latent constructs and to determine the quality of each item.

Funds of Knowledge Scale

We identified six themes using interview data: community networks, connecting experiences, tinkering knowledge, perspective taking, reading people, and mediational skills.

We define *community networks* as the general advice, resources (material or non-material), and support that members of students' community provide to aid them in their engineering coursework. Community networks encompass four subthemes: students' family members, networks at work, neighborhood friends, and university friends. Each of the four subthemes prompted students to indicate to what extent the following statements were true using a 7-point anchored numeric scale from 0- "Not at all true" to 6- "Very True." Sample items for each subtheme of community networks include, "Friend(s) from my neighborhood have given me resources that helped me in my engineering coursework," "Friend(s) in my current school have given me resources that helped me in my engineering coursework," "Family member(s) have given me resources that helped me with my engineering coursework," "Coworker(s) or mentors have given me resources that helped me with my engineering coursework." Students were also asked if at any point in time they had a job, which helped us understand if the subtheme of networks at work pertained to them.

Connecting experiences pertain to students' ability to draw from hobbies or home environment activities to scaffold what they are currently learning in engineering. Students were asked to indicate to what extent did they agree or disagree with the following statements using a 7-point anchored numeric scale from 0- "Strongly disagree" to 6- "Strongly agree." Sample items for connecting experiences include, "I see connections between my hobbies and what I am learning in my engineering coursework (e.g. design projects, homework, exams, presentations)" and "I draw on my previous experiences at home when little instruction is given on how to solve an engineering task."

Tinkering knowledge consists of two subthemes: knowledge from home and knowledge from work. Tinkering knowledge from home relates to activities (i.e., repairing, assembling, or building) that students have engaged within their home environment. Tinkering knowledge from work pertains to activities (i.e., fixing, assembling, or building) that students have engaged within a work-related environment. For both subthemes, students were asked to indicate to what extent do they agree or disagree with the following statements using a 7-point anchored numeric scale from 0- "Strongly disagree" to 6- "Strongly agree." Example of items for tinkering knowledge from home and work are, "At home, I learned to use tools to build things" and "At work, I learned to work with tools."

Perspective taking refers to a cognitive capacity to examine a situation or examine another person's experience. The survey items for this theme were taken from a larger survey scale by Gerdes et al [11]. Here, students were asked how accurate the following statements described them using a 7-point anchored numeric scale from 0- "Very inaccurately" to 6- "Very accurately." Example of perspective taking items are, "I am open to listen to the point of view of others" and "I like to ask people questions about their experiences."

Reading people involves using non-verbal cues (i.e., body language and emotional state) to understand others or situation. For this theme, students were also asked how accurate the following

statements described them using a 7-point anchored numeric scale from 0- "Very inaccurately" to 6- "Very accurately." Sample items for reading people include, "I am good at decoding other people's body language" and "I can identify other people's concerns without having to ask them directly."

Lastly, the theme *mediational skills* encompass students' ability to help others "sort things out" when in an unfamiliar situation or circumstance. Students were asked, at any point in your life, how likely were you to have done the following using a 7-point anchored numeric scale from 0- "Not at all likely" to 6- "Extremely likely." Examples of questions pertaining to mediational skills include, "Help different groups of people better understand each other" and "Help different individuals on a team better understand each other."

Additional Survey Scales Used in the Final Survey

In addition to the funds of knowledge scale, the final survey was comprised of several previously validated scales (i.e., certainty of career trajectory, engineering identity, sense of belonging, engineering agency, among others). The scales were selected based on their contribution to the overall research objective of this project, which is to understand how first-generation college students' funds of knowledge contribute to their engineering work and success. In the sections below, we describe the different scales that we used, with all scales being grounded in existing literature and previously validated in other research studies.

Certainty of Career Trajectory

According to Bandura [12], "people's level of motivation, affective states, and actions are based more on what they believe than on what is objectively true" (p. 2). Certainty of career trajectory is based on students' beliefs about graduating with an engineering degree, obtaining the necessary knowledge to succeed in their career, and obtaining their desired engineering job. Variations of these survey items have been used in prior work [13], [14].

Engineering Identity

We used the engineering role identity scale developed by Godwin [15]. The development of an engineering identity can be understood through three interrelated constructs, having an interest, internal and external recognition as someone that can do engineering, and beliefs about understanding the content material and performing well. This scale has been used to understand first-generation college students engineering identity by Verdín et al., [16] and [17].

Sense of Belonging

The scale for a sense of belonging comes from two sources Smith et al., [18] and Boone and Kirn [19]. A sense of belonging is present in multiple domains, for example, belonging to one's university community and/or belonging in the classroom setting [16].

Engineering Agency

Engineering agency involves using engineering as a tool towards (re)shaping an individual's community or world around them through everyday actions "(e.g., using their knowledge of science/engineering to design solutions for their community)" [20, p. 4]. This scale was recently validated with first-generation college students.

Future Work

We are currently in our second data collection process. The large-scale survey will be administered to engineering students both upper and lower classmen at three participating institutions across the United States (i.e., large public polytechnic, large sub-urban public, and large public universities) and four Mathematics, Engineering, and Science Achievement (MESA) Engineering Programs. MESA Engineering Programs admit students who are the first in their families to attend a four-year university and/or are low-income making it an ideal place to maximize our sample of first-generation college students. A confirmatory factor analysis will be conducted on the funds of knowledge scale to finalize validity evidence of the scale. After the funds of knowledge scale has been validated, we will continue forward in answering the research questions.

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References

[1] E. T. Pascarella, C. T. Pierson, G. C. Wolniak, and P. T. Terenzini, "First-Generation College Students: Additional Evidence on College Experiences and Outcomes," *The Journal of Higher Education*, vol. 75, no. 3. pp. 249–284, 2004.

[2] W. Tyson, "Negative Impact of Employment on Engineering Student Time Management, Time to Degree, and Retention: Faculty, Administrator, and Staff Perspectives," *J. Coll. Student Retent. Res. Theory Pract.*, vol. 13, no. 4, pp. 479–498, 2012.

[3] M. W. Ohland, M. K. Orr, V. Lundy-Wagner, C. P. Veenstra, and R. A. Long, "Viewing access and persistence in engineering through a socioeconomic lens," in *Engineering and Social Justice in the University and Beyond*, C. Bailie, A. L. Pawly, and D. Riley, Eds. West Lafayette, IN: Purdue University Press, 2012, pp. 157–180.

[4] V. Lundy-Wagner, C. P. Veenstra, M. K. Orr, N. M. Ramirez, M. W. Ohland, and R. A. Long, "Gaining Access or Losing Ground? Socioeconomically Disadvantaged Students in Undergraduate Engineering 1994-2003," *J. Higher Educ.*, vol. 85, no. 3, pp. 339–369, 2014.

[5] J. M. Smith and J. C. Lucena, "Invisible innovators: how low-income, first-generation students use their funds of knowledge to belong in engineering," *Eng. Stud.*, vol. 8629, no. March, pp. 1–26, 2016.

[6] J. Smith and J. Lucena, ""How Do I Show Them I'm More Than A Person Who Can Lift Heavy Things?" The Funds Of Knowledge Of Low Income, First Generation Engineering Students," *J. Women Minor. Sci. Eng.*, vol. 22, no. 3, pp. 1–45, 2016.

[7] G. Zhang, T. J. Anderson, M. W. Ohland, and B. R. Thorndyke, "Identifying Factors Influencing Engineering Student Graduation: A Longitudinal and Cross-Institutional Study," *J. Eng. Educ.*, no. October, pp. 313–320, 2004.

[8] C. P. Veenstra, E. L. Dey, and G. D. Herrin, "Is Modeling of Freshman Engineering Success Different from Modeling of Non-Engineering Success?," *J. Eng. Educ.*, no. October, pp. 467–479, 2008.

[9] T. Nomi, “Faces of the Future: A Portrait of First-Generation Community College Students,” 2005.
[10] J. Ma and S. Baum, “Trends in community colleges: enrollment, prices, student debt, and completion,” *Coll. Board Res.*, pp. 1–23, 2016.
[11] K. E. Gerdes, C. A. Lietz, and E. A. Segal, “Measuring empathy in the 21st century: Development of an empathy index rooted in social cognitive neuroscience and social justice,” *Soc. Work Res.*, vol. 35, no. 2, pp. 83–93, 2011.
[12] A. Bandura, *Self-efficacy: The exercise of control*. New York: W.H. Freeman and Company, 1997.
[13] D. Verdín, A. Godwin, G. Sonnert, and P. M. Sadler, “Understanding how First-Generation College Students ’ Out-of-School Experiences , Physics and STEM Identities Relate to Engineering Possible Selves and Certainty of Career Path,” in *IEEE Frontiers in Education*, 2018.
[14] D. Verdín and A. Godwin, “The Relationship Engineering Identity and Belongingness on Certainty of Engineering Major for First-Generation College Students,” in *Paper presented at the 2019 annual meeting of the American Educational Research Association*, 2019.
[15] A. Godwin, “The Development of a Measure of Engineering Identity,” *123rd Am. Soc. Eng. Educ. Annu. Conf. Expo.*, p. 15, 2016.
[16] D. Verdín, A. Godwin, A. Kirn, L. Benson, and G. Potvin, “Understanding How Engineering Identity and Belongingness Predict Grit for First-Generation College Students,” 2018.
[17] D. Verdín and A. Godwin, “First-Generation College Students Identifying as Future Engineers,” in *Paper presented at the 2018 annual meeting of the American Educational Research Association*, 2018.
[18] T. F. Smith, D. Wilson, D. Carlson, M. Plett, R. Bates, and N. Veilleux, “Investigation of Belonging for Engineering and Science Undergraduates By Year in School,” *2012 ASEE Annu. Conf. Expo.*, pp. 1–11, 2012.
[19] H. Boone and A. Kirn, “First Generation Students Identification with and Feelings of Belongingness in Engineering,” *2016 ASEE Annu. Conf. Expo.*, pp. 1–27, 2016.
[20] A. Godwin and G. Potvin, “Pushing and pulling Sara: A case study of the contrasting influences of high school and university experiences on engineering agency, identity, and participation,” *J. Res. Sci. Teach.*, vol. 54, no. 4, pp. 1–24, 2016.