Board 299: Impact of Socialization on Graduate Student Education

Dr. Arvin Farid, Boise State University

Dr. Arvin Farid is a Professor of the Civil Engineering Department and the Director of the SEnS-GPS Program, sponsored by the U.S. National Science Foundation, at Boise State University. He is also the chair of the Geoenvironmental Engineering Technical Committee of the American Society of Civil Engineers (ASCE) Geo-Institute (GI) and an editor of the Environmental Geotechnics Journal of the Institute of Civil Engineers (ICE). He also serves on several national and international committees. He received his Ph.D. from Northeastern University, Boston, MA, and his M.Sc. and B.Sc. degrees from Shiraz (formerly Pahlavi) University, Shiraz, Iran. He has pioneered the leading edge of research on the use of electromagnetic (EM) fields for geoenvironmental/geotechnical applications. His research includes EM-induced remediation, EM waves' effect on soil properties, energy geo-storage, wildfire research, recycling and reuse of industrial byproducts, material characterization, power infrastructure vulnerability, liquefaction mitigation, and engineering education, among others. His most recent research focuses on wildfires' impacts, resilience against them, restoration and remediation post-fire, and recycling waste. Dr. Farid was awarded several research grants from the U.S. National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA) among others. He has published in several prestigious civil and electrical engineering journals and presented at numerous international civil engineering, electrical engineering, and geophysics conferences.

IMPACT OF SOCIALIZATION ON ENGINEERING GRADUATE EDUCATION

Abstract: According to congressional reports in 2005 and 2010 (Rising Above the Gathering Storm Committee, 2010) and the National Science Foundation's State of US Science and Engineering (NSB, NSF, 2022), the number of graduates of Science, Technology, Engineering, and Mathematics (STEM) programs at all levels does not meet the need of the industry. This need is more urgent at the graduate, specifically, the master's level (NSF, NSB, 2022). Our goal has been to create and institutionalize best practices for the recruitment, retention, and timely graduation of master's students to create a sustainable pipeline to address this need at the graduate level. Hence, we attempted to expand this pipeline by creating an environment that attracts, supports, and retains historically or traditionally marginalized or minoritized and diverse populations. According to the literature, there are a series of activities that are proven for the recruitment and retention of low-income and academically talented, and/or first-generation and historically or traditionally marginalized or minoritized populations (LIATFGURM) students at the undergraduate level (Hernandez et al., 2018; Kendricks et al., 2019; Lisberg & Woods, 2018). However, this has not been validated at the graduate level. Therefore, the Scholarships for Engineering Graduate Students Program (SEGSP; pseudonym) was crafted to support these populations in pursuing a master's degree in engineering.

This study seeks to explore ways in which SEGSP can impact recruitment and retention in engineering master's programs by attending to components of socialization (Weidman et al., 2001). The scholars in this program are Master's students in the College of Engineering, and the institution is an R2 (doctoral university with high research activity) university. Thus, the utilization of the graduate- and professional-student socialization framework—for this Master's level program—was in response to the fact that LIATFGUR students often report inequitable socialization opportunities (Roksa et al., 2018). The results of this study can potentially inform stakeholders who seek strategies to recruit and support LIATFGURM students in graduate programs.

INTRODUCTION

The number of Science, Technology, Engineering, and Mathematics (STEM) jobs in the U.S. has outpaced non-STEM jobs since 2010 and is predicted to continue to do so into the near future (National Science Board [NSB], National Science Foundation [NSF], 2022). However, universities are struggling to meet the demands of STEM industries for qualified workers at all levels.

While there has been a drastic increase in the number of advanced degrees awarded in STEM in the U.S. in recent years, research and development, a key component of increasing national capacity for innovation, largely requires a population with advanced degrees, and specifically master's degrees (NSF, NSB, 2022).

Creating a sustainable pipeline and institutionalizing best practices for the recruitment, retention, and timely graduation of master's students who will directly go into industry after graduation is crucial. To expand this pipeline, an environment that attracts, supports, and retains historically or traditionally marginalized or minoritized and diverse populations needs to be created. Despite the research on successful support systems for the recruitment and retention of low-income and/or first-generation and historically or traditionally marginalized or minoritized and diverse populations (LIFGUR) students at the undergraduate level (e.g., Hernandez et al., 2018;

Kendricks et al., 2019; Lisberg & Woods, 2018), the effectiveness of these activities at the graduate level has not been evaluated. Therefore, the SEGSP program was created specifically to recruit and support academically talented, low-income students (targeting LIFGUR populations) in pursuing a master's degree in engineering.

This study seeks to explore the impact of socialization on recruitment and more closely retention in engineering master's programs (Weidman et al., 2001). The scholars in this program are Master's students in the College of Engineering, and the institution is an R2 (i.e., doctoral university with high research activity) university in terms of research level. Thus, the utilization of the graduate- and professional-student socialization framework—for this Master's level program—was in response to the fact that LIFGUR students often complain about inequity in socialization opportunities (Roksa et al., 2018). Specifically, the research question guiding this study is: *In what ways do recruitment and retention strategies that attend to aspects of socialization theory support LIFGUR students' recruitment and retention in STEM graduate programs?"* The results of this study can inform the recruitment and retention of LIFGUR students in graduate programs.

METHODOLOGY

This study was undertaken with a mixed-methods design to "draw from the strengths and minimize the weaknesses of both" qualitative and quantitative research methodologies (Johnson and Onwuegbuzie, 2004). In this section, we will briefly describe the setting and participants, the SEGSP intervention, and data collection and analysis for this study.

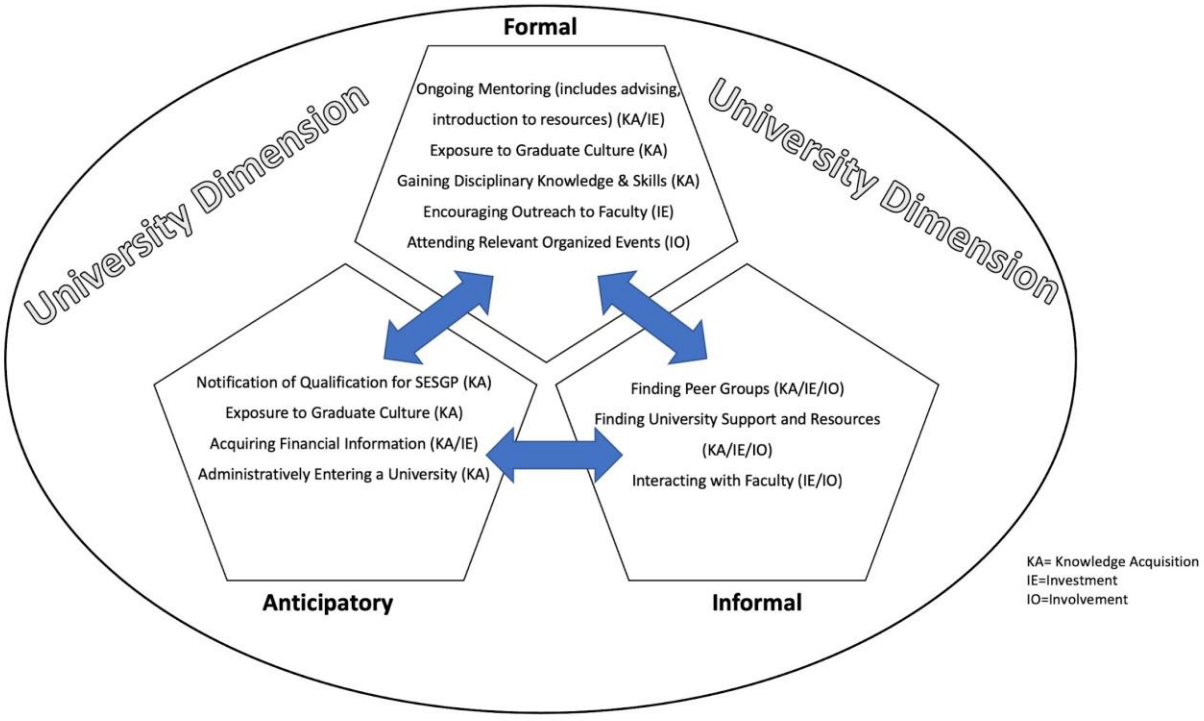

Figure 1. *Components of Socialization in SEnS-GPS*

SETTING AND PARTICIPANTS

This research took place at Boise State University, a university in the Western U.S. with 24,000 students, including approximately 3,000 graduate students. Roughly 75% of the graduate student population identifies as White, 7% as Hispanic, 2% as Black/African American, and 2% as Asian. U.S. citizens constitute 93% of the graduate population, and 38% of the graduate population attends full-time.

There are two populations of participants in this study. The first population is the students supported by the scholarships (SEGSP), hereafter, referred to as scholarship participants (*S*). The second population is comprised of graduate students in the College of Engineering not supported by the SEnS-GSP, hereafter, referred to as general engineering students (*G*). This research took place during the 2020-2021 and 2021-2022 academic years. The demographics of the *S* and *G* students for these years can be found in Table 1.

Table 1. Demographics of the population in this study

	S*: 2020-2021	***G*: 2020-2021**	***S*: 2021-2022***	***G*: 2021-2022**
Total Enrolled in Relevant Programs	10 Students	144 Students	10 Students	191 Students
Self-Identified Gender	8 Females (80%) 2 Males (80%)	54 Females (38%) 90 Males (62%)	8 Females (80%) 2 Males (20%)	66 Females (35%) 125 Males (65%)
IPEDS Ethnicity	0 Asian (0%) 0 Black/African American (0%) 3 Hispanic (30%) 0 Nonresident Alien (0%) 0 Unknown (0%) 1 Two or More Races (10%) 6 White (60%)	11 Asian (8%) 1 Black/African American (1%) 6 Hispanic (4%) 35 Nonresident Alien (24%) 2 Unknown (1%) 6 Two or More Races (4%) 83 White (58%)	0 Asian (0%) 0 Black/African American (0%) 3 Hispanic (30%) 0 Nonresident Alien (0%) 0 Unknown (0%) 1 Two or More Races (10%) 6 White (60%)	10 Asian (5%) 2 Black/African American (1%) 10 Hispanic (5%) 35 Nonresident Alien (18%) 4 Unknown (2%) 6 Two or More Races (3%) 123 White (64%)
historically or traditionally marginalized populations or minoritized populations in STEM‡	4 Students (40%)	7 Students (5%)	4 Students (40%)	10 Students (7%)

First Generation College Student	5 Students (50%)		4 Students (40%)	

* Note that there have been fifteen distinct *S*, but due to the overlapping nature of the cohorts, ten students were enrolled in 2020-2021 and 10 students were enrolled in 2021-2022.
‡ The University defines 'historically or traditionally marginalized populations or minoritized populations in STEM' as "Domestic students who identify as one or more of the following ethnic backgrounds or races: African American/Black, Hispanic/Latino/a, Native American/Indian, Alaska Native, or Pacific Islander (includes Filipinos)."

INTERVENTION

The SEGSP support system consists of three key components: (i) financial: a scholarship for up to four semesters of the graduate program; (ii) extensive proactive advising (Kraft-Terry & Kau, 2019) via an assigned mentor as well as the program coordinator, (second author); (iii) College of Engineering and Graduate College offerings relevant to students with opportunities to attend social, professional, and academic development activities.

Once enrolled in the program, students were invited to attend an orientation, referred to as Graduate Shopping Day, which consisted of resource presentations, faculty introductions, and community-building activities.

The last orientation event each fall is a retreat. This retreat occurred over three days and included community-building activities along with program preparation, mental health and well-being workshops, and deep dives into important resources available to graduate students.

On average, there are two activities hosted each month (e.g., a social event, and industry panels). Additionally, students are required to check in with the program coordinator once each month and their faculty advisor twice each month.

DATA COLLECTION

Surveys containing both qualitative and quantitative data were collected to study the impact of the First Year and Other activities.

First-Year Surveys

All new graduate students in the College of Engineering (*S* and *G*) were asked to complete the First-Year Survey as they entered their program. This survey was repeated every semester for these students over the three following semesters. The survey consisted of 10 questions asking about their motivations for enrolling in their program, career aspirations, motivations, supports, and barriers. Barriers and supports were rated on a 4-point Likert scale responding to, "To what extent have the following factors supported you/served as barriers to you in considering and/or attending the graduate program(s) indicated above?" (1 = not at all; 4 = a great deal). Statements about these supports and barriers were then phrased as "I" statements (e.g., "I can keep up with the workload of graduate school," "I have a mentor"), and students were asked to rate their level of agreement on a 4-point Likert scale (1=never; 4=always).

Activity Surveys

Multiple times each semester, all graduate students in the College of Engineering (*S* and *G*) were given an Activity Survey. Students were given a list of fourteen common activities (e.g., Meeting with an academic advisor; Attending an event hosted by the Graduate College), as well as a place to indicate an 'Other' activity or to indicate that they did not participate in any activities for the time range indicated on the survey. Students were asked whether they saw these activities as beneficial (if they provided students with a sense of community) or if there were other activities they would like to see happening. This survey has been conducted eight times.

Field Notes

S students are required to meet with the program coordinator twice each semester. The first meeting is a general check-in and guidance meeting while the second one serves as another check-in and opportunity to plan for future coursework and activities. The content of these meetings generally involves general check-in and get-to-know questions, mental health check-in, faculty-advisor-relationship check-in, home-life check-in, coursework progress, Capstone assignment progress, planning for the next semester, and student understanding of the next steps.

Focus Group

All students were asked to participate in a 40min-long focus group via Zoom. The focus group included questions ranging from topics like their motivation to attend graduate school and communications they received before and during the program, to supports and barriers to success and whether they had forged relationships with their peers.

RESULTS, ANALYSIS, AND DISCUSSION

The survey results have been collected every semester but do not fit within the scope of this paper. We received a total of 11 and 36 first-year responses from *S* and *G* participants, respectively. We also received a total of 44 and 61 activity responses during the following years, respectively.

Data Analysis

Quantitative Data Analysis

The First-Year Survey results were analyzed using the Mann-Whitney U test to determine if the means of the distribution of each response on the survey were significantly different between S and G participants. The Mann-Whitney U test—often compared with the parametric *t-test*—is a flexible, nonparametric method that does not assume a normal distribution of the data (MacFarland & Yates, 2016). Furthermore, nonparametric distribution tests—the Kolmogorov-Smironv test and Kruskal Wallis test—were also used as auxiliary sources of information to examine the similarity of the distribution of survey results of *S* and *G* participants (McKight & Najab, 2010; Fasano and Franceschini, 1987).

The Activity Survey results were analyzed using Boschloo's, Barnard's, and Fisher's exact tests to determine if *S* students were significantly more likely to participate in a certain activity than *G* students. Boschloo's and Barnard's exact tests are unconditional exact tests for two independent binomial variables, which are uniformly more powerful than Fisher's exact test that requires both margins (sum of rows and columns) to be defined apriori to the sampling (Ludbrook,

2013). Fisher's exact test is more conservative compared to the other two exact tests, given its strict constraints on both margins (Lydersen et al., 2009) and its potentially spurious categorization of significant associations as statistically insignificant.

Qualitative Data Analysis

The open-ended portion of responses to the surveys were analyzed using the constant comparative method (Glaser, 1965). After themes related to recruitment and retention were generated, those themes were compared between the *G* and *S* participants to explore the impact of the SEGSP support system. These data were also analyzed in a constant comparative method (Glaser, 1965) as well, with attention given to items related to recruitment and retention. Finally, the field notes were analyzed using the constant comparative method (Glaser, 1965) to look for patterns arising in the data across students.

Findings

To answer our research question, the recruitment, enrollment, and graduation statistics regarding both *S* and *G* populations were first studied. Then, the remainder of the findings section was organized by the stage in the framework of graduate- and professional-student socialization (Weidman et al., 2001; 2003; 2006) that the University can impact, i.e., anticipatory, formal, and informal. Within each stage, the core elements the University can impact (knowledge acquisition, investment, and involvement)— and students report as supportive—will be discussed.

Recruitment and Retention Statistics

To date, although the numbers of students in the SEGSP are small, they are promising. Of fifteen students who have been part of the SEGSP since Fall 2020, eight have graduated within the four semesters of funding support and two others have graduated but went beyond the four semesters of support. One student was dismissed from SEGSP due to a low GPA (but has since graduated) and one student changed from a master's program to a doctoral program (even though considered a success, this makes him ineligible for SEGSP). The three remaining students are in their second year (third semester) of the program and are anticipated to graduate on time. None of the students originally enrolled in SEGSP have dropped out of their graduate programs.

When strictly looking at those who have graduated from SEGSP in the expected timeframe (8/15), there is a 53% graduation rate. When looking overall at those who have stayed in their master's program and graduated (11/14), there is a 79% graduation rate for SEGSP.

Comparatively, in the College of Engineering, graduates complete their degrees in 5.44 semesters on average. The data is still being analyzed, and the results will be published in a future journal article.

CONCLUSIONS

Undergraduate education has received a great deal of attention and resources, but graduate education—despite progress being made—is still lagging in terms of attention and resources received (Pascale, 2018). We argue that programs focusing on graduate-student socialization, such as the SEGSP, would accomplish these tasks and more. To support and acclimate students to a degree program, an institution, and a discipline, students should feel a sense of belonging and will be engaged more deeply in their work and relationships. As shown in the results to date,

such students have a much more positive experience in graduate school and a higher chance of persisting to a degree and onto the workforce.

ACKNOWLEDGMENT
This project was supported by the National Science Foundation, NSF, through the DUE Program, Award No. 1930464. The authors appreciate the support by the NSF and its DUE program.

REFERENCES

U.S. Bureau of Labor Statistics (2018). *Educational attainment for workers 25 years and older by detailed occupation*. Retrieved from https://www.bls.gov/emp/tables/educational-attainment.htm.

Fasano, G. & Franceschini, A. (1987). A multidimensional version of the Kolmogorov–Smirnov test. *Monthly Notices of the Royal Astronomical Society, 225*(1), p.155-170.

Glaser, B. G. (1965). The constant comparative method of qualitative analysis. *Social Problems, 12*(4), 436–445.

Hernandez, P. R., Bloodhart, B., Adams, A. S., Barnes, R. T., Burt, M., Clinton, S. M., Du, W., Godfrey, E., Henderson, H., Pollack, I. B., & Fischer, E. V. (2018). Role modeling is a viable retention strategy for undergraduate women in the geosciences. *Geosphere, 14*(6), 2585–2593. https://doi.org/10.1130/ges01659.1

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher, 33*(7), 14–26.

Kendricks, K. D., Arment, A. A., Nedunuri, K. V., & Lowell, C. A. (2019). Aligning best practices in student success and career preparedness: An exploratory study to establish pathways to STEM careers for undergraduate minority students. *Journal of Research in Technical Careers, 3*(1), 27. https://doi.org/10.9741/2578-2118.1034

Kraft-Terry, S., & Kau, C. (2019). Direct measure assessment of learning outcome–driven proactive advising for academically at-risk students. *NACADA Journal, 39*(1), 60–76. https://doi.org/10.12930/nacada-18-005

Lisberg, A., & Woods, B. (2018). Mentorship, mindset, and learning strategies: An integrative approach to increasing underrepresented minority student retention in a STEM undergraduate program. *Journal of STEM Education, 19*(3), 14–20.

Ludbrook, J., 2013. Analysing 2× 2 contingency tables: which test is best? *Clinical and Experimental Pharmacology and Physiology, 40*(3), pp.177-180.

Lydersen, S., Fagerland, M.W. and Laake, P., 2009. Recommended tests for association in 2× 2 tables. *Statistics in medicine, 28*(7), pp.1159-1175.

MacFarland, T.W. and Yates, J.M. (2016). *Introduction to nonparametric statistics for the biological sciences using R*. Springer.

McKight, P.E. and Najab, J., 2010. Kruskal-Wallis test. In I.B. Weiner & W. E. Craighead (Eds.) *The corsini encyclopedia of psychology*, pp.1-1, Wiley.

Merolla, D. M., & Serpe, R. T. (2013). STEM enrichment programs and graduate school matriculation: The role of science identity salience. *Social Psychology of Education, 16*(4), 575–597. https://doi.org/10.1007/s11218-013-9233-7

Murdock, J. L., Stipanovic, N., & Lucas, K. (2013). Fostering connections between graduate students and strengthening professional identity through co-mentoring. *British Journal of Guidance and Counselling, 41*(5), 487–503. https://doi.org/10.1080/03069885.2012.756972

National Science Board, National Science Foundation. 2022. *Science and Engineering Indicators 2022: The State of U.S. Science and Engineering.* NSB-2022-1. Alexandria, VA. Available at https://ncses.nsf.gov/pubs/nsb20221

Olson, K. J., Huffman, A. H., & Litson, K. (2021). The relationship between mentor support experiences and STEM graduate student career optimism. *Career Development International, 26*(1), 44–64. https://doi.org/10.1108/CDI-07-2019-0171

Pascale, A. B. (2018). “Co-existing lives”: Understanding and facilitating graduate student sense of belonging. J*ournal of Student Affairs Research and Practice, 55*(4), 399–411. https://doi.org/10.1080/19496591.2018.1474758

Piatt, E., Merolla, D., Pringle, E., & Serpe, R. T. (2019). The role of science identity salience in graduate school enrollment for first-generation, low-income, underrepresented students. *Journal of Negro Education, 88*(3), 269–280.

Rising Above the Gathering Storm Committee. (2010). *Rising above the gathering storm, revisited: Rapidly approaching category 5.* National Academies Press.

Roksa, J., Feldon, D. F., & Maher, M. (2018). First-generation students in pursuit of the PhD: Comparing socialization experiences and outcomes to continuing-generation peers. *Journal of Higher Education, 89(*5), 728–752. https://doi.org/10.1080/00221546.2018.1435134

Weidman, J. C. (2006). Socialization of students in higher education: Organizational perspectives. In C. F. Conrad & R. C. Serlin (Eds.), *The SAGE Handbook for Research in Education* (pp. 252–262). SAGE Publi. https://doi.org/10.4135/9781412976039.n14

Weidman, J. C., & Stein, E. L. (2003). Socialization of doctoral students to academic norms. *Research in Higher Education, 44*(6), 641–656. https://doi.org/10.1023/A:1026123508335

Weidman, J. C., Twale, D. J., & Stein, E. L. (2001). Socialization of graduate and professional students in higher education: A perilous passage? *ASHE-ERIC Higher Education Report, 28*(3). http://files.eric.ed.gov/fulltext/ED457710.pdf