

A Systematic Literature Review of the Research on Gendered Socialization in Graduate Engineering Education

Sarah Allison Grajdura

Sarah is a postdoctoral researcher at the Institute of Transportation Studies, University of California Davis. Her research interests combine sustainable transportation, natural disasters, transportation equity, and engineering education. She holds a Ph.D. in civil environmental engineering from University of California Davis.

Kacey Beddoes (Project Director)

Kacey Beddoes, Project Director, San Jose State University College of Engineering Dean's Office and Research Foundation. Kacey serves as Managing Editor of Engineering Studies, Deputy Editor of the Australasian Journal of Engineering Education, and is Past Chair of the SEFI Working Group on Gender and Diversity. She holds a Ph.D. in Science and Technology Studies from Virginia Tech, along with graduate certificates in Engineering Education and Women's Studies. Her current research focuses on gender, interdisciplinarity, and mental wellness in engineering and engineering education. Further information about her work can be found at www.sociologyofengineering.org.

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Introduction

Across various contexts, socialization processes and practices have been shown to play key roles in education and career outcomes, satisfaction, and trajectories. Numerous ways in which gender intersects with and structures socialization processes, practices, and experiences have also been identified. Graduate and post-graduate education in particular likely have their own socialization patterns which influence graduate student experience and outcomes. We are interested in the intersection of gender and socialization in graduate education.

In this paper, we examine the research landscape of gendered socialization in a graduate engineering education context and identify potential areas for research growth. We also review the different ways in which socialization is theorized and approached in this field. This paper is organized in three parts. The first part broadly maps the landscape of gendered socialization in engineering education. In the second part of the paper, we systematically review the subset of articles on graduate and post-doctoral engineering education, focusing on their findings and approaches. Lastly, we offer recommendations to advance this field.

Methods

We perform a systematic literature review, which consists of the search, selection, coding, and synthesis of information. The primary search process consisted of procuring articles related to engineering and socialization through Academic Search Complete (ASC) and Web of Science. To identify the initial dataset, we searched within the title, abstract, or keywords for terms indicated in Table 1 below, which resulted in $n = 262$ articles. Next, we narrowed down this pool of articles to those focusing only on gender using a second search, shown below in the righthand column of Table 1. This process limited the article pool to $n = 56$ articles.

Table 1. ASC and Web of Science primary search

Initial Search Terms	Gender Search Terms
1. Engineering and socialization 2. Engineering and socialisation	• Gender • Sex • Wo(men) • (Fe)male • Girl • Femin- • Masculin-

We further limited this pool to only those papers focusing on graduate and postdoctoral education by manual selection. This process left us with a dataset of seven articles, which are fully listed in the Appendix. In the following section we present a landscape mapping of the larger 56-article dataset. A full text of one article was unable to be procured before writing this article, hence it was excluded from our dataset; we are still trying to procure the full text.

Landscape Mapping

We are interested in the field of gendered socialization in engineering education research, so in this section we broadly map this landscape with a meso-level analysis. We consider the geographic origins and methods within this landscape. The majority of these articles ($n = 40$) are from the year 2012 or later, which indicates this field is somewhat new. These 56 papers mainly focus on K-12 education and undergraduate education, with graduate education and the workplace studies both appearing less frequently than K-12 and undergraduate studies.

Table 2 below indicates the geographic origins for the group of 56 articles. Most of the articles ($n = 34$) come from the United States. Fewer articles come from the United Kingdom, Spain, and Croatia, as well several other primarily European countries.

Table 2. Geographic origins

Country	Number
United States	33
United Kingdom	3
Spain	2
Croatia	2
Australia, Canada, China, Germany, Ghana, Ireland, Japan, Jordan, Luxembourg, Netherlands, Norway, Singapore, Turkey	Each 1
International collaborations: Chile & Spain, Malaysia & UK, USA & Brazil	Each 1

The most common data collection techniques (Table 3) were surveys and interviews, which accounted for over half ($n=32$) of the studies. Other popular techniques included literature review, focus groups, and diaries. Several articles combined more than one method, especially interviews, which were combined with participant observation, focus groups, diaries, and surveys. Fifteen studies used longitudinal data, while $n = 41$ studies used one-time data collection or were literature review articles. This is important to note given that socialization is a *process*.

Table 3. Data Collection Methods

Method	Number
Survey	22
Interview	10
Literature Review	7
Interview & Survey	3
Interview & Focus Group	3
Focus Group	2
Interview & Participant Observation	2
Interview & Diary	2
Diary, Experiment, Game design & Survey, Photovoice, Survey & Literature Review	Each 1

Systematic Review

In this section, we present the systematic review of the graduate and post-doctoral gender and socialization articles. The seven articles and their details such as author, year, topic, education level, methods, and research approach are listed below in Table 4. We compare the characteristics of our smaller graduate dataset to that described in the landscape mapping: three of the seven papers originated in the United States, with one paper originating in Japan, the UK, China, and India, respectively. The dataset is composed of papers only within the fields of education and business, with the majority (6) from the education field. A diverse combination of methods are used in our dataset. Two papers used quantitative methods, two used mixed methods, and three used qualitative methods. For data collection, the quantitative papers relied on surveys while the mixed methods papers paired surveys with interviews. The qualitative studies relied on interviews or interviews paired with focus groups or participant observation.

Chakraverty (2020) examined how imposter syndrome manifests among STEM post-docs using a mixed methods approach. The post-doc sample was mostly female and white. The interview analysis revealed several themes among post-docs: not pursuing new things, not making social connections, impaired communication, not applying to positions, procrastination and mental health, and the feeling of undeservedness/lack of qualifications [1]. The author notes that future work on imposter syndrome among post-docs should focus on targeting underrepresented groups.

Hosaka (2020) studied the socialization of newcomer female engineering graduate students in Japan. The findings illustrated that research experience was a main reason for pursuing a graduate degree in engineering. Another important theme is learning how to become a part of their unique research unit through socialization. The study also found that women faced a harder time integrating into their research unit, as they were treated differently than male students [2].

Sallee (2011) examined how socialization may be gendered, through masculine norms and culture, in a graduate department. The author focused on male doctoral students in an aerospace engineering department, instead of focusing on women. The findings show masculine values guiding socialization, especially hierarchy and competition, and that students are encouraged to have large egos and be argumentative [3]. The author finds that the culture “simultaneously excludes and objectifies women”, and the socialization experiences of men and women differ [3].

Blaney et al. (2020) consider the role of post-docs in mentoring and interacting with graduate students. The primary themes were (from most to least mentioned): instrumental support, psychosocial support, the mistreatment of post-docs serving as a warning of pursuing an academic career, and the power of a post-doc to set the culture in a lab setting [4]. The results indicate that in addition to a primary advisor, post-docs play an important role in socializing and supporting graduate students. The authors indicate that faculty and post-docs could work together to provide cascading mentorship to graduate students.

Considering engineering graduate education’s connection to industry, Lee and Miozzo (2015) examined the effects of industry-related doctoral projects. The authors discover that these types of projects are better-received by industry and provide better industry-specific social networks. Of

note however, is that while these projects may be viewed more highly in the private sector, they also resulted in fewer publications compared to non-industry projects [5].

Yang and Shen (2020) examined socialization differences for male and female students as well as gender matching between students and their advisors in Chinese STEM Master's programs. They find that male students had more access to research projects than female students, creating a "disadvantaged socialization for female graduate students" [6]. Female students paired with female advisors were more productive than male students. Generally, female students reported being more satisfied with communication than male students. Male students were more likely to pursue a doctorate. Further results varied by specific sub-field studied.

Examining relationships between faculty and graduate students belonging to underrepresented minority groups, Posselt (2018) finds that faculty were used primarily for psychosocial support, specifically for discussing the difficulties of graduate school, helping to reduce anxiety. Students did not report going to faculty for academic support as often. Faculty also served to validate students' abilities, reducing self-doubt, and provide honest race and gender conversations [7].

Looking at this subset of articles, several topical themes emerge. Three of these articles (Chakraverty, Hosaka, and Posselt) address imposter syndrome and feelings of inadequacy felt by graduate students. Two of the articles (Sallee, and Yang & Shen) specifically look at the socialization differences between male and female students and address a prevailing masculine cultural norm in STEM departments. Two of the articles (Blaney et al., and Posselt) also look at ways that mentorship, through faculty advisors and post-docs, can help graduate students.

Table 4. Dataset Details

Author (year)	Topic	Level	Methods	Data Source	Longitudinal
Blaney et al. (2020)	Relationship between doctoral students & postdocs	Doctoral & Postdoc.	Mixed methods	Interview & survey	Yes
Chakraverty (2020)	Imposter syndrome among postdocs	Postdoc.	Mixed methods	Interview & survey	No
Hosaka (2010)	Women's experiences in engineering research	Master's	Qualitative	Interview	No
Lee & Miozzo (2014)	Industry collaboration's effect on career trajectory	Doctoral	Quantitative	Survey	Yes
Posselt (2018)	Faculty support for doctoral students	Doctoral	Qualitative	Interview & focus group	No
Sallee (2011)	Gender in doctoral student socialization	Doctoral	Qualitative	Interview & participant observation	No
Yang & Shen (2020)	Effect of gender on STEM master's students in China	Master's	Quantitative	Survey	No

The articles have different approaches to investigating gender and socialization, which is likely due to how these articles conceptualize socialization in relation to their research questions. For six out of the seven articles, socialization is seen as a process which occurs in the background as an implication of the factors being investigated, rather than the main topic of study. For example, Blaney et al. (2020) investigate the relationship between doctoral students and post-doctoral scholars in laboratory settings, while Posselt et al. (2018) look at faculty support of graduate student well-being. In both of these examples, socialization is a process which occurs, but not necessarily *the* topic of study in its own right. However, Sallee (2011) takes a different approach, looking at socialization as a rich topic to be explored and understood, investigating the relationships between gender, doctoral students, and socialization directly. In fact, Sallee lays out the ways in which socialization itself is gendered in this space, providing the example of how socialization reinforces masculine values in aerospace engineering, elevating competition and hierarchy.

Sallee (2011) also explores how gender non-conforming students have differential experiences due to their identity not aligning with the prevailing masculine socialized culture. This type of research opens the door and provides a segue into the need for research on intersectionality, since a masculine socialized cultural norm likely contains aspects of other norms relating to race, class, sexuality, etc. as well. For students not conforming to different aspects of these norms, the experience can be vastly different, as Sallee observes. Graduate students and post-doctoral scholars may experience different socialization based on intersectional privilege or marginalization. Hence, it is important that these pervading norms, which are replicated and maintained through gendered socialization, be explored. In order to study topics that are bound up with socialization, as the other six articles do, it would make sense to first understand the socialization process better, specifically how it is gendered and how different students experience socialization. Collaborating with scholars from sociology or gender studies could be one way to expand research in these important directions.

Recommendations for Future Research

In this section, we identify several potential directions for growth in the space of gender, socialization, and graduate engineering education. First, the field could benefit from additional diverse methodologies beyond analysis of interviews and surveys. We recommend more diversity within the research methods and approaches undertaken to study this topic, beyond interviews and surveys. Since the study of socialization in this space is rather new, researchers may find phenomenological methods, or methods that are generally less constrained, to be especially useful. Socialization is a *process* that unfolds over time, hence longitudinal data collection techniques are ideal, which many articles in the larger dataset noted [1], [2], [8]–[13]. However, less than 30% of the larger and final datasets relied on longitudinal data. We recommend future studies use longitudinal data collection techniques.

Second, more intersectional graduate socialization research is needed that addresses race or ethnicity, socioeconomic status, sexuality, and nationality within socialization, as well as the socialization experiences of those who do not conform to gender or other norms [14]. Recent

research has shown how important such issues are in the workplace [15], [16], and similar understandings of intersectional privilege and marginalization in graduate education are needed.

Third, socialization likely depends on the country or region and disciplinary context in which it occurs, and how gender and other aspects of intersectionality are viewed in that environment. Since much of the research is US-based, it could be enlightening to conduct comparative socialization studies among different countries, engineering disciplines, etc.

Fourth, this research space would benefit from more research into the socialization process itself and how it is gendered. Since socialization likely varies across different groups of students, it is important we connect socialization patterns with aspects such as academic performance, career outcomes, program retention, etc. It would be interesting to revisit several of the research questions of the selected articles while taking into account the heterogeneous effects of socialization on graduate students and post-docs. As an example, Chakraverty (2020) investigated imposter syndrome among post-docs in STEM; instead, investigating how masculine socialization affects imposter syndrome among post-docs would likely unearth new understandings of this issue which better highlight the underlying phenomena.

Several other research horizons seem promising as well:

- Future studies that examine those who leave graduate engineering programs and their experiences with socialization hierarchies could provide important insight into graduate engineer retention.
- As engineering departments have diversified, it is important to understand how socialization has changed, if at all. (How) has the masculinity of socialization changed over time with increased diversity? Has this impacted the norms which socialization upholds, or are graduate students still being socialized in the traditional manner?
- Similarly, given the recent increase in work from home from 2020 onwards, how has socialization changed for engineering graduate students with reduced in-person contact?
- Lastly, there are opportunities for more systematic and comprehensive characterization of graduate student socialization, including by drawing on models and instruments from engineering workplace socialization.

For our future work, we will be writing a systematic review of the entire engineering socialization dataset and identifying findings that can be used to improve the engineering education system.

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Appendix: Graduate Gender & Socialization Dataset

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