



Female International Students in Engineering: A Qualitative Review

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ABSTRACT

CONTEXT

When international students relocate overseas to pursue higher education, they undergo transitions in social culture, educational approaches and professional practice. These transitions shape various aspects of their identity (e.g., personal, professional), engineering identity being one of them. Engineering identity is a complex, contested construct that informs how engineering is perceived, how education curricula are developed, and which student it attracts. Due to stereotypes about engineering, white middle-class males continue to dominate the profession. However, there is a need for a more diverse engineering workforce that better represents the society. With female international students' varied journeys and intersectional identities, a closer look at this population will shed light on ways to attract and retain diverse individuals within engineering.

PURPOSE OR GOAL

As a first step in a larger study about understanding the identities and experiences of female international students, in this paper we ask the following research question: What research has been conducted on female international students in engineering?

APPROACH OR METHODOLOGY/METHODS

As a starting point, the following keywords (and their synonyms) are searched on Scopus and targeted journals: 'international student', 'wom*n', 'engineer*'. After the abstracts are screened based on their relevance to the research question, the remaining abstracts are analysed to determine an appropriate scope for this review, and the inclusion and exclusion criteria are refined. References from the included papers are screened and analysed using the same process.

ACTUAL OR ANTICIPATED OUTCOMES

Based on the search strategy as well as inclusion and exclusion criteria, 6 papers were identified as relevant to the research question, and the findings were qualitatively analysed based on two categories: university and family/society. Discussion on university focussed on female international students' interactions in the social and academic context, while discussion on family/society focussed on the impact of societal perceptions of engineering and gender roles on female international students.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

The paucity of relevant literature from the initial search strategy suggest that female international students in engineering are understudied. The findings suggest that this population's experience has been underrepresented in both the literature on international students and women in engineering. We conclude with a call for more studies to investigate more nuanced accounts and narratives of female international students in engineering to better inform pedagogical approaches and interventions.

KEYWORDS

International Student, Literature Review, Gender

Introduction

When international students relocate overseas to pursue higher education, they undergo transitions in social culture, educational approaches and professional practice. While the onus is usually on international students to adapt to these transitions, their economic, social, and cultural contributions to their host countries have prompted further research to attract international students (Department of Education and Training, 2016). Topics that are well covered in the literature of international students include their experiences with adjustment (Burns, 1991), with some focussing on the acculturation process (Dervin, 2011). Several scholars have also studied (perceived) differences in educational approaches (Chalmers and Volet, 1997), and more recently there has been a rise in literature discussing strategies to support international students (Ryan, 2005). While there is a wide spectrum of research on international students, many of them are heavily practice-based, which limits the applicability of findings in a different context (e.g., a different host country with different demographic of international students).

Within engineering, women account for only 17% of university enrolment, the lowest across STEM education in Australia (Australia Academy of Science, 2019). Extensive research on women in engineering has been undertaken to tackle the issue of under-representation and address the barriers to participation. However, several quantitative studies have shown that there is little to no gender difference among international students' enrolment in engineering compared to domestic students (Miner, 2019), and that gender gaps in mathematics are not present in all nations (Else-Quest et al., 2017). These findings suggest that there is a need to take a closer look at women from abroad who choose to study engineering. Furthermore, as international students, they face multiple layers of marginality as racial/ethnic minority and foreigners whose first language may not be English (Lim et al., 2021).

As a first step in a larger study about understanding the identities and experiences of female international students, in this paper we ask the following research question: *What research has been conducted on female international students in engineering?*

Method

Search Strategy

To better understand the range of literature on female international students in engineering, we searched for the following sets of terms on Scopus without applying a date range:

Term 1: wom*n OR female OR gender

Term 2: international student OR overseas student OR foreign student

Term 3: engineer* OR STEM

From the 52 results, only 4 of them were directly relevant to all three sets of search terms. Many of the results covered two aspects (e.g., international students doing engineering but lack a gender lens, women in engineering but not international students), which do not answer the research question.

To enhance the relevance of the literature, we extended the search to include targeted peer-reviewed journals, for example:

- Searching for Term 1 & Term 2 in the Journal of Engineering Education, European Journal of Engineering Education and Australasian Journal of Engineering Education
- Searching for Term 1 & Term 3 in the Journal of International Students and Journal of Studies in International Education

While the intention was to search for literature that included studies of international students of diverse nationalities and women in engineering in different countries, we found that the

different framing of this population in different contexts, as well as the focus on literature published in English made it hard to achieve. However, we recommend doing so as part of a future study.

Inclusion and Exclusion Criteria

In the process of screening the literature, we applied the following criteria to refine the scope of the paper:

- Excluding literature that focusses only on race, as students from underrepresented racial/ethnic background who were brought up in the country where the institution is based have significantly different experiences to international students who travel to the host country and adapt to potentially unfamiliar cultures and approaches
- Excluding literature on professionals in the workplace, as the purpose of this review is to better inform pedagogical approaches rather than workplace practice
- Excluding students who are engaged in short-term study abroad programs, as they are often not in an unfamiliar context for long enough to undergo significant transitions in identity

Findings and Discussion

The purpose of this study is to develop a preliminary understanding on an underrepresented population. We conducted a qualitative review, which is “a method for comparing the findings from qualitative studies, where accumulated knowledge resulting from this process may lead to the development of ... an overarching ‘narrative’,” with the goal of broadening understanding of a particular phenomenon (Grant and Booth, 2009).

Table 1 summarises the literature that was analysed. Details on each study’s target population are noted under Context. However, as each study framed the cultural contact of their participants differently, we have only noted the cultural contact in instances where it applies to the entire study. This is done to prevent stereotyping a particular culture based on a participant’s statement, considering that most studies are drawn from international students of diverse nationalities and are based on theoretical frameworks that are not centred on cultural models.

Table 1: Overview of Relevant Literature

Author	Title	Source	Context	Research Question(s)
Anderson-Rowland et al. (2007)	Encouragers and discouragers for domestic and international women in doctoral programs in engineering and computer science	Proceedings of American Society for Engineering Education 2007 Conference	Doctoral students; international women	How does being a woman play a role in your progress through the doctoral program? What types of things happen in your days that encourage you to keep going in your program? What types of things happen in your days that discourage you from continuing in your program?

Dutta (2015)	Sustaining the pipeline: experiences of international female engineers in US graduate programs	Journal of Engineering Education	Graduate students; US institution; international female	What are the discursive practices in which international female engineers engage when faced with gendered constructions, policies, procedures, and organizing processes in engineering graduate programs of study?
Dutta (2016)	Negotiations of cultural identities by Indian women engineering students in US engineering programs	Journal of Intercultural Communication Research	Graduate students; US institution; Indian international students	How do Indian women engineering students negotiate their cultural identities in US engineering programmes?
Dutta (2017)	Cultural barriers and familial resources for negotiation of engineering careers among young women: relational dialectics theory in an Asian perspective	Journal of Family Communication	Graduate students; US institution; Asian	What, if any, competing discourses inform the choice of gendered careers such as engineering in Asian familial narratives from the perspective of women engineers? How do these narratives resist the dominant discursive assumptions about young women's engineering careers?
Gupta (2012)	Women undergraduates in engineering education in India: A study of growing participation	Gender, Technology and Development	Undergraduate students; Indian institution	Not explicitly stated – the paper argues against the simplistic notions of the masculine image of science and engineering, and suggests that a culture-specific picture would include the intersection of “market forces, dynamically developing social changes, gender, and technology”

Lim et al. (2021)	Walking on gender tightrope with multiple marginalities: Asian international female students in STEM graduate programs	Journal of International Students	Graduate students; US institution; Asian female international student (AFIS)	How do AFISs envision the role of gender and foreign nationality in their STEM program experiences? How do AFISs cope with or counteract the challenges derived from their embodied marginalities, gender, and foreign nationality inevitably complicated with their race/ethnicity?
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University

Based on the literature summarised in Table 1, participants' experiences in the university setting are often studied as they spend a considerable amount of time there. Generally, participants from both Dutta's (2016) and Lim's (2021) studies initially had a positive outlook on their host country (United States), which is perceived to be more gender equitable compared to their home countries. However, several participants from Dutta's (2016) study found themselves more marginalised and less valued by men classmates in the US compared to men classmates (where they did their undergraduate degrees) in India, while participants from Lim's (2021) study gradually learnt about their marginal status as an Asian international female student (AFIS).

The findings from the above literature are categorised into several sections: *interactions in social context*, *interactions in academic context*, *coping strategies and support mechanisms*. Academic context refers to settings such as classrooms and labs where formal learning and research takes place, while social context more fluidly describes other environments both in and out of the university where education is not the core activity, or is conducted informally.

Interactions in social context

Participants from Dutta's (2015) study expressed that they found it harder as an international women student to connect with their peers within the engineering program. As it was easier for international men students to find peers with shared interests, they would meet each other outside of class and know each other better. While some of the participants were friends with men, it did not feel as comfortable as being friends with women due to underlying social norms on relationships with the opposite gender (Dutta, 2016).

The tension in relationships with the opposite gender extends to teaching staff as well, where participants felt that they had nothing in common with the teaching staff apart from their studies (Dutta, 2015), and found that men supervisors tend to be friendlier with men in the program (Anderson-Rowland, 2007). These experiences resulted in women feeling socially disconnected with academics and consequently, disengaged with the program especially if they already had a hard time understanding lectures as international students.

Interactions in academic context

A participant from Dutta's (2016) study found it hard to vocalise her thoughts and participate in classroom discussions. She felt that many classmates saw her as incapable because she is a woman from abroad, which highlights the role of this participant's intersectional identity in her academic experiences. This was consistent with the experiences of several other participants in the lab, where they did not feel included and that their contributions were

needed (Dutta, 2015). While the participants in Anderson-Rowland's (2007) study hesitate to get help with manual work in the lab, they shared that men of certain cultures expected women to clean up after them in the lab and do menial tasks. However, participants from Dutta's (2015) study also reported on positive experiences, such as the willingness of peers to take time answering questions from women in labs and understanding that international students may require more time to adapt.

Apart from their interactions with peers, participants from Dutta's (2016) study reported on experiences where men teaching staff questioned their abilities and long-term interest in pursuing an engineering profession. Some of them assumed that upon degree completion, participants will embark on a career in software engineering/information technology, or get married and stop working, hence using it as a justification to not take them seriously and prioritise men for conference opportunities (Dutta, 2016). This account emphasises how an academic's assumption on an international woman student's interests can be a detriment to their engineering career, and how they play a role in further exacerbating the perception that women engineering students are not 'cut out' for engineering (Dutta, 2016). However, one participant mentioned that her professor believed in her and took extra time to mentor her, which gave her the confidence to stay in engineering (Dutta, 2016).

Participants' roles in the academic context are not limited to those as a student being taught or supervised, but also as an academic in tutor or Teaching Assistant (TA) roles. A participant in Lim's (2021) study, who is a TA that is still developing her English language proficiency, shared her experiences with implicit microaggression and explicit disrespect by noncompliant undergraduate students. Not only do these participants face marginalisation by their peers as mentioned previously, undergraduate students refuse to acknowledge their expertise despite them being employed as a TA.

Reflecting on their program's effort to increase women's enrolment and retention by giving them an advantage, participants from Lim's (2021) study felt less confident about their competence. They often wonder if their acceptance to the program was intended as a push for more international students to generate more revenue for the higher education institution, or because they were women. Participants from both Dutta's (2015) and Lim's (2021) studies were cognizant that inclusion is sometimes used as departmental agenda to portray diversity. One participant spoke about how women in her cohort were nominated for their reports due to the higher probability of them getting an award. While the nomination is encouraging, the participant did not see it as recognition (Dutta, 2015). Participants from Lim's (2021) study also shared this sentiment on how their perceived advantage could obscure the merit and qualification for an award. This would lead to their hard work getting overlooked (Lim, 2021) and the need for women to prove they were as good (Anderson-Rowland, 2007).

Coping strategies and support mechanisms

In response to the experiences faced by participants across these studies, participants cited varied coping strategies and support mechanisms. One participant in Dutta's (2015) study selectively worked with other international women students. Other participants further elaborated on the importance of support from groups like the Women in Engineering Society (Dutta, 2015) and their respective ethnic community or common cultural institution (Lim, 2021). These support mechanisms were backed by participants in Anderson-Rowland's (2007) study, who found associating with a group of students from their home countries encouraging. Overall, there is a consensus that knowing others with similar experiences (whether it is a fellow woman in a male-dominated degree program or a senior student with a shared cultural background) helps to derive strength that they can overcome current challenges. A participant from Lim's (2021) study further explained how seeing that there are people that "look and talk different" makes her feel comfortable, alluding to the importance of a diverse environment in creating a safe space for students.

Apart from getting support through communities mentioned above, participants from Lim's (2021) study also raised the need for academic support in the form of mentoring. Due to the

lack of international women faculty members, mentoring in their program is often limited to peer mentoring as faculty members with immigrant or transnational backgrounds are more willing to work with international women students. Participants from Dutta's (2015) study found networking to be a great way to boost self-efficacy, suggesting a possibility in using networking as a mechanism to address the challenge raised by Lim's (2021) participants on low international women faculty member numbers. In the absence of staff availability, Anderson-Rowland (2007) concluded that an encouraging advisor will act as an encourager for these participants.

Family/Society

Based on the literature summarised in Table 1, family plays a key role in determining participants' choice of degree and career. In the context of this paper, 'family' and 'society' are used interchangeably as "cultural discourses, which produce and reproduce gendered career expectations, pervade familial understanding of careers" (Dutta, 2017). The findings are categorised into several sections: *factors contributing to the desirability of engineering, perceptions on engineering and gender fit, support and negotiation to pursue engineering.*

Factors contributing to the desirability of engineering

In Gupta's (2012) study on women engineering undergraduates in India, they found that 68% of respondents chose engineering due to its job prospects, with only 27% citing interest as a reason for doing engineering. This finding was consistent with several participants' statements in Dutta's (2017) study, where having an engineering career is their parents' preferred choice (for both sons and daughters) due to its prestige, and their belief that engineering will ultimately lead to social mobility and respect in society. The qualitative data from Dutta's (2017) study complements Balakrishnan's (2014) quantitative survey, where Japanese and Malaysian women engineering students reported strong encouragement by their parents and family members to pursue a career in engineering. Participants from Dutta's (2017) study also spoke about their parents' encouragement for daughters to study math/science as a subject in school to appear smarter. These findings contrast the challenges faced in Western contexts, where girls report significantly lower interest and confidence levels in math/science (Else-Quest et al, 2010).

These considerations are overlaid with marriage prospects in contexts where families play a huge role in finding and selecting a spouse for their children. On the one hand, having a higher education qualification increases a bride's value in the marriage market (Gupta, 2012). On top of its perceived prestige, engineering is also favoured for its 'friendly' image in the Indian context, which "makes it easier to fix a daughter's marriage" (Gupta, 2012). However, since a match in educational and professional qualifications is a key criteria when finding a suitable spouse, there are additional concerns for women who study engineering overseas, as it will be hard to find a spouse that matches the participants' overseas qualification as an engineer.

Perceptions on engineering and gender fit

The above concerns add to many reasons engineering is discouraged for women, which are typically associated with families' perceptions on engineering. They include the below perceptions on engineering:

- Engineering involves hard work like "hauling machines and picking up big boulders" which women will not have the energy for (Dutta, 2017)
- Engineering is unsafe as it involves being on sites like bridges and tunnels (Dutta, 2017)
- Engineers have to work in the field for days "in the middle of nowhere" where amenities are lacking (Dutta, 2017)
- As an engineer, they will be the only woman among men, which is frowned upon in cultures where women should not be around men without supervision (Dutta, 2017)

One participant shared her father's concern on engineering as he favoured career options that provides "comfort, safety and stability" (Dutta, 2017), which is associated with computer-related subjects and careers that tend to be office-based and does not require physical strength (Gupta, 2012). These preferences extend to families' decision for their daughters' education as well, with one participant sharing her parents' and relatives' desire for her to go to a nearby college rather than study interstate (Dutta, 2017), and another participant's experience with her parents disapproving her decision to live alone in an unfamiliar area despite being accepted to a prestigious institution.

Support and negotiation to pursue engineering

Where participants receive support to study engineering, it usually comes from their parents (Dutta, 2016). In most cases, these parents are not bothered by gender expectations imposed by the society they are part of, such as their relatives' suggestion for women to study subjects with more women like Medicine or English, or their grandparents' concerns on engineering interfering with their marriage (Dutta, 2017). In many cases, parents prioritised what their daughters want despite being unfamiliar with engineering (Dutta, 2017). In some cases, parents actively endorsed engineering for their daughters by bringing them to engineering talks and training them to understand the mechanics of objects around them. One participant's mother, who did engineering herself, would share stories from her past experience in engineering, which helped the participant develop confidence to overcome the challenges faced in engineering school (Dutta, 2017).

In these cases, what is notably absent in the participants' families' considerations on engineering is a woman's ability to do well in science/math, which tends to be one of the primary concerns in the Western context despite studies that show no gender differences on mathematics achievement (Else-Quest et al., 2010). One participant in Dutta's (2017) study shared that her father believes that she would be good at anything she puts her mind to, including engineering. It is also worth noting that most parents and relatives prioritise education equally for both sons and daughters to the extent of investing in private education (Gupta, 2012).

It is important to recognise that all of the above points are not standalone factors of why women are encouraged or discouraged by their family to pursue engineering. A common thread that was found across many participants in Dutta's (2016) study, who were primarily of Asian descent, was the juxtaposition of their personal concerns on career and family concerns on marriage. Some participants were expected to meet potential matches set up by their parents on top of their hectic study/work schedules (Dutta, 2016), while others reported having their academic/career achievements overlooked due to the notion that women's lives are only deemed as a success when they get married and have children (Dutta, 2017). Many participants constantly walk a fine line between building an engineering career and fulfilling parental obligation, and some participants land on 'negotiated deals' – for example, they are allowed to study engineering only if they are set on working in IT (deemed as a safer and more stable career choice) and getting married upon graduation (Dutta, 2017). While there are cases where parents are supportive of participants pursuing a career in engineering, they encourage participants to get married upon graduation in consideration of their old grandparents (Dutta, 2017).

Conclusion and Future Research

In this study, we provided a preliminary overview of the research on female international students in engineering, specifically through the lens of their interactions within the university and with their family/society. While most of the participants are based in US institutions, we found that including family/society in the larger picture of this research shed light on several culturally-informed blind spots in most of the literature on women in engineering as well as quantitative studies which treated female international students as a homogenous population, collapsing the diversity to simple binaries of domestic versus international, or

male versus female. We conclude with a call for more studies to investigate more nuanced accounts and narratives of female international students in engineering to better inform pedagogical approaches and interventions.

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