

Studying Engineering Abroad: Intersectionality and Student Support

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Abstract—What is it like to study engineering in Ireland when you are female and you come from somewhere far away, in the Middle East, which has different social customs and norms? What is your lived experience? What aspects of the experience are common to Middle Eastern women across your course? As education researchers, we aim to understand the essence of the experience these foreign women have had studying engineering in Ireland—what life has been like for them and what unique challenges they have faced that may be invisible to us as instructors. This article reports preliminary analysis of 13 interviews that we conducted with eight women from Kuwait and Oman during their first three years studying engineering in Ireland. It is geared toward educators—teachers, administrative staff, and support providers—who want to better understand the experiences and perspectives of international students. The paper culminates with advice distilled from literature and our own analyses regarding how to support students working in groups, with an eye toward helping international students achieve success and feel supported and included.

Keywords—women, diversity, nontraditional students, student development, international students

I. INTRODUCTION

To begin this exploration of how students experience engineering classrooms when they are considered to be minorities, we explore recent research regarding female students working in groups, particularly during Problem-Based Learning (PBL). We consider how gender can intersect with factors of race and ethnicity and how this can influence students' experience studying science, technology, engineering and mathematics (STEM).

Looking first at gender, research by Fowler and Su [1] and Hirshfield [2] indicates distribution of tasks on group engineering project assignments often reflects unconscious bias—students may be unaware they are distributing tasks along gender lines, even when it is evident to observers. Students often fail to see and/or fail to report bias when they allocate tasks across a team and subsequently assess their team members' work. Students in a study by Hirshfield [2] claimed, in interviews and written team assessments, to have had effective collaboration and equitable, unbiased allocation of tasks. Yet, the researcher contrasted this with observations and various interview narratives that reflected gender-bias. She found evidence of gender bias in team dynamics and assignment of roles. Women and men reported the same levels of confidence and satisfaction with their teams, as well as reporting being fair and unbiased. Nevertheless, Hirshfield recommended teachers take action to achieve better inclusion by looking beyond student self-reports, considering how bias

and stereotypes might be in play, and how these might influence what types of work students get exposed to and in what areas they develop mastery. Likewise, Fowler and Su [1] found relationships between gender and “goal orientation” that lead individuals to select or avoid certain tasks. This led to teams distributing tasks along gender lines. Fowler and Su developed a conceptual model for allocating tasks, so that students working in teams could help overcome gender bias.

In a study by Neumann, Lathem, and Fitzgerald-Riker [3] of persistence in environmental and civil engineering programs, women recognized that the time and project management, group coordination, and communications they provided had value to the team. When it came to technical tasks, they often found themselves assisting or supporting their male teammates.

Ethnicity and socio-economic status can also affect the experiences of students and teachers. Gupta, Garg, and Kumar [5] analyzed ratings assigned to teachers by male and female students in India. These ratings were intended to measure the quality of teaching delivered. The researchers identified statistically significant differences, which included same-gender as well as cross-gender biases. The differences corresponded to the socio-economic status and gender of the teachers. Likewise, US-based research of teaching evaluations undertaken by Potvin et al [6] revealed significant interaction between a student's socio-economic status and gender, and the teacher's socio-economic status and gender.

Research by Brainard and Carlin [8] found that women who entered into STEM majors were high achievers with high levels of self-confidence who filtered themselves toward STEM. However, experiences in their majors during their first two years caused a significant drop in their confidence levels. A subset of these women left their STEM course due to feelings of non-acceptance, loss of interest in the content, lowered self-confidence in a competitive environment, or experience with bad advising.

How does this drop in confidence happen? A US study conducted in the US by Wilkins-Yel, Simpson, and Sparks [9] regarding the resilience of women engineers and engineering PhD students found that participants felt dismissed, ignored, and unacknowledged when working alongside men in small groups in both work and academic settings. Moreover, Tonso [10] found that in engineering classrooms, use of profanity, and violent or semi-sexual metaphors and insinuations, even when not intended to offend, contributed to the hostile and/or chilly climate experienced by female engineering students.

Adding to this, being a female student from a foreign country can result in feeling alone, outside, or other than the

norm. All the dynamics discussed above can influence students' perception of how they fit, if they belong, and whether or not they should stay in engineering. Wyer [7] found that when women experienced an unwelcoming academic environment, their commitment to stick it out in STEM was lower than for women who felt accepted.

Middle Eastern countries differ greatly from one another with regard to gender expectations and levels of gender segregation. Kuwait and Oman dictate lower levels of separation than Saudi Arabia, for instance. Researchers in Saudi Arabia have investigated the experiences of female students taught by male engineering teachers and studying in classrooms with partition walls that physically separate female students from their male teachers. Research by Elhussein, Düstegör, Nagy, and Alghamdi [4] showed that the digital technologies employed to help overcome the physical barriers did not always achieve desired aims—in fact, female students said they sometimes avoided casting light on their faces that the teacher might see. When they wanted to keep their identity hidden, they avoided using digital devices. This affected learning (by reducing their access to support) and left teachers unable to verify the identity of attendees.

This article focuses on two specific research questions: *What led this group to study engineering? How did they experience PBL and learning in groups?* These questions form one facet of a larger study that has enabled us to develop a list of recommendations, included in this paper, for educators seeking to support diverse students in their classrooms and PBL projects.

II. CONTEXT AND DESIGN OF THE STUDY

In the academic year 2014-2015, we conducted interviews with female engineering students at TU Dublin, to explore their experiences with collaborative learning in engineering. After our first round of hour-long interviews, we realized the Middle Eastern students in the cohort were describing much different experiences than those who had attended Irish secondary schools. We decided to conduct additional interviews with the women from the Middle East to follow up.

This article shares what these women told us in their first, second, and third years (we have the final year yet to analyze). We interpret how their narratives might inform student support, team formation, and content delivery. Essentially this paper summarizes findings reported by Chance and Williams [11, 12, 13] and literature generated via a special focus issue of *IEEE Transactions in Education* guest edited by Chance, Bottomly, Panetta, and Williams [14].

A. Participants

In this paper, we report analysis of the interviews we conducted with eight Middle Eastern women who were studying engineering in Ireland. All came from Kuwait or Oman, and all were practicing Muslims and Arabic speakers. This was part of a larger study that included a total of 48 women enrolled in third-level STEM courses in Ireland, Portugal, and Poland. This sub-set of eight women had enrolled simultaneously in the four-year general entry engineering Bachelor of Engineering (Honours) course that divides into three major streams at the second year (civil/structural, mechanical, or electrical and electronic) in TU Dublin, in Ireland (an institution then known as Dublin Institute of Technology). Ethics approval was granted by the appropriate committee of the institution.

B. Methods

Following the initial phenomenological analyses, we conducted additional interviews with women from the Middle East during their third year of study. With the first three years' worth of data, we then conducted grounded theory analysis using constant comparative methods to identify themes and then group these themes. We did this with the support of NVivo software. Here, we report initial preliminary findings of analysis of 13 of the 20 interviews conducted with this particular sub-set of students.

III. ADDRESSING THE RESEARCH QUESTIONS

This section and the following one synthesize findings we reported in more detail in previous publications [11, 12, 13] and include quotations from participants where relevant.

A. What led this group to study engineering?

Seven of the eight Middle Eastern participants had studied in gender-segregated schools in Kuwait and Oman. None of them studied or socialized with boys outside their immediate families during childhood. All had studied English while they were in school, but only two of them had encountered any academic subject conducted in English prior to arriving in Ireland. Thus, despite having studied advanced physics and mathematics, they had learned Arabic scientific terms rather than English ones. They encountered unfamiliar terms in their new Irish classrooms.

Enjoyment of practical, hands-on learning as well as maths encouraged these women to consider taking an engineering course. During secondary school, they dedicated time to selecting an appropriate sub-field of engineering.

Participants said there were many women in engineering in their countries. It is a good career path for women, they asserted, particularly since engineering jobs were plentiful and they felt women were quite welcome in the engineering jobs in their countries. Their governments clearly encouraged school graduates, female as well as male, to pursue engineering and provided generous funding. They foresaw themselves as engineers, working in teams with men and women from many parts of the world, and communicating in English at work. Both medicine and engineering degrees were seen as good choices, and ones they had considered when applying to university.

Parents were described as having an important supporting role in their higher education choices and activities. They encouraged their daughters to select subjects that would ensure them an adequate level of future independence. Participants valued what members of their families had to say about various career options and study destinations.

Interviewees explained they would return home after graduation from TU Dublin, to work and complete internships in the construction, manufacturing, or energy sectors. They envisioned being able to balance work and motherhood and marriage. They planned to reside with parents until getting married.

B. How did they experience PBL and learning in groups?

This section explores challenges and preferences regarding their engineering studies. Adjusting to the group, project-based, student-centered, self-directed learning and teaching methods used at the university required them to adjust on academic as well as personal levels. They encountered difficulty with the pedagogy as well as the

language, amount and complexity of work, logistics of living in a new place (and getting used to the money, arranging their own housing, and navigating the transport system). They also felt homesick at times, and worried about letting others down at home or in their classes.

The tutors they had in their first year proved to be particularly supportive—the participants visited these tutors for advice frequently over the years. When asked, they said they perceived no bias regarding gender, race, or ethnicity from their teachers. They did, however, have some trouble understanding their teachers' accents and speed of talking and tendency to scribble on the board. They also had trouble when teachers used terms and references familiar to Irish students, but unfamiliar to them. Many things that teachers assumed all students would know were novel to them, as some terms do not translate directly from Arabic to English and material culture and symbolism are much different where they come from. Other challenges involved managing a heavy workload and determining when and how to ask for help or for clarification from teachers. In many cases, they found clearer answers from classmates than from teachers, and they described their peers (Irish, international, and Arabic) as very kind and helpful.

Unlike interactions with teachers, when it came to group work, gender stood out as a major concern. Starting in their first year, they had to work in groups with male students. Some of them were placed alone as the sole women on the team and encountered problems. When working in groups with men, they often felt their ideas were not being heard, their voices were lost, the boys were moving ahead too quickly without considering alternatives, and they weren't sure how to communicate their frustration when this happened. By the time they reached third year, however, they had numerous experiences in teams of varying composition. Most of them had experienced being the only female on a team but had learned ways to approach this. Nonetheless, they identified advantages of being in teams with another female, especially in their early years; they appreciated having a woman to bounce ideas off, to improve ideas with before pitching them "to the boys", and to back them up when they faced challenges.

With regard to group projects, frustrations had to do with:

- feeling excluded, unheard, ignored, or deemed inherently wrong due to their gender;
- feeling rushed or seeing the men on the team adopt ideas without considering what they felt were enough options;
- being the sole woman in the group or, alternatively, experiencing teams with only women, where they felt there was an inadequate range of abilities, skills, interests, and perspectives;
- laziness or lack of follow-through on the part of others or of themselves, feeling they were abandoned and left to do most of the work;
- managing demanding deadlines and workloads.

Whilst learning to work in groups, interviewees came to understand the benefits of diversification as well as peer-to-peer learning. In fact, teaming up in a homogenous group sometimes proved troublesome. Teams without native English speakers struggled to produce work at the quality these

participants wanted to see. Participants avoided being in teams comprised entirely of Arabic members, as they felt people in these teams assumed they would take up the slack and they ended up with disproportionate amounts of work. They said even their friends would leave an unfair share of work to them.

They voiced the perception that Irish students were good people to team with; they carried their fair share of the load and delivered on time. Their overall preference was working in teams of diverse ethnicities that included native English speakers.

When teachers left team selection up to the students, they encountered trouble, as the home students tended to invite others like themselves, which left the non-Irish students to fend for themselves. Ending up on a group of all Arabic or all international students left their team at a deficit, they felt. Such teams were seen to lack the necessary range of soft (communication and teamwork) and hard (technical, engineering) skills they desired. For instance, "*When they let us choose our groups, the boys go and choose themselves—like a boys' group—and we're left with just the girls*", one participant explained. She liked best for the teacher to compose the groups, with consideration of members' skills and abilities. They wanted opportunities to work with Irish and other English-speaking students. The same student explained that having mixed groups "*is much better because you know, we have to improve our language. That's one part of this, when we work with English or Irish group, because you have to speak English at that time and you will improve your language, even listening to them. It's positive.*"

Over the years, they practiced and got use to communicating and working with male students. They expanded their group of friends and acquaintances, but they also keep in close contact with the core group of female Arabic students they had entered the engineering program with. They also kept in contact with the Middle Eastern friends, female and male, they met during English studies and pre-university foundation studies they did in Dublin prior to entering the engineering course.

Sources of enjoyment/satisfaction derived from their time studying engineering in Dublin were academic as well as personal and family related. They found satisfaction in practical and hands-on learning, successfully speaking in public, and learning from mistakes. They described feeling joy and a sense of excitement in learning. Exploring new possibilities, reconsidering their boundaries, and setting their own limits also proved satisfying. They found it necessary to "break" some of the rules they were used to at home—this was a necessary part of learning in the university environment, especially in engineering and in course that used a group, problem-based approach. They provided incredibly rich descriptions of their initial encounters communicating with male students in the university setting (classroom, labs and canteens). They described increased levels of confidence and independence over time, and their instructors bolstered their sense of accomplishment by noting things they had done well. They described becoming more aware of their own personal values and honing their individual identities in ways that bridged their home and host cultures. A highlight for several was being part of Irish host families over the years they lived in Dublin. Being part of these families significantly enhanced their time in Dublin, several explained. Host mothers and other international students staying in the host homes were central figures in their stories, but host brothers and host

fathers were also important. Some participants stayed in host families from pre-college until graduation, while others lived with their own family members who also studied in Dublin or who came to live in Ireland to support them. Some eventually gave living with Arabic friends a try. They rented apartments, often via lists their Embassies provided. Their Embassies in Dublin also helped arrange hosts.

IV. DISTILLING LESSONS LEARNT

In this section, we consider what we have learned from this study that might help engineering educators like ourselves to more effectively support diverse students. First, we return to Fowler and Su [1] as their study, awarded Best Paper for all articles published in *IEEE Transactions in Education* in 2018, provides relevant advice. Then we share what changes we have made in our own classrooms in response to what we observed, heard in interviews, and read in the literature.

A. Advice from Fowler and Su

Based on thematic analyses of reflections submitted by 60 students completing an introductory engineering module, Fowler and Su found that “individual student characteristics that are related to gender—including interests, skills, experiences, and self-efficacy—interact with students’ goal orientations to lead to individual preferences regarding tasks. Ultimate task allocations are distributed in a non-gender-neutral way” (p. 312). They produced a conceptual model indicating that students’ initial preferences regarding the various tasks that needed to be done by the team were affected by individuals’ interests and experiences, as well as the skillsets they perceived themselves to have (i.e., their sense of self-efficacy). These factors (interests, experiences, skillsets, and self-efficacy) “are then interpreted through an academic orientation filter, which affects how those skills and experiences affect task preferences” (p. 313). One student might be more oriented toward performance and getting a high mark (performance orientation) whereas another might be more orientated toward developing new abilities (mastery orientation). All these factors and perceptions will feed into the team’s negotiations and influence how the individual and the individual’s peers interact as they endeavor to allocate tasks.

Students of minority status can be more adversely affected at this point than others, “as their teammates’ perceptions of them affect what they might feel ‘allowed’ to do on a team, or they might self-select into particular roles. In this way, team-based learning can actually endanger students’ self-confidence and perception of themselves as engineers and computer scientists” Fowler and Su argued (p. 316). Via reflective essay, more women than men reported avoiding technical tasks they perceived as difficult, taking a disproportionate share of the project management and communication-related tasks. This was particularly problematic on teams that used a “divide and conquer” approach to task distribution.

Overtime, students’ skills, interests, and sense of self-efficacy shift, and this feeds into their updated task preferences for subsequent negotiations. This cycle means that some students will continually accept tasks where they already have developed skills, rather than put their team at risk of failing, or themselves at risk of embarrassment. In their reflection statements, this type of task avoidance was expressed by women and men alike. Fowler and Su found this meant over time, male students practiced and thus developed

technical skills more often in team projects, whereas female students practiced and developed management and communication skills more often. Fowler and Su recommend that teachers: (1) seek to affect students’ academic orientations; (2) seek to disrupt power dynamics during team negotiations; or (3) intentionally assign students to specific roles. By encouraging students to set goals and master new skills, teachers help students reflect on their abilities and goals and challenge themselves to take risks rather than seeking safety. Teachers can ask students to share, in teams, their goals and report progress. As the way students are assessed influences their willingness to take academic risks, teachers might also think about decreasing the emphasis on the product and increasing emphasis on the process and the learning.

In the research Fowler and Su conducted, students reported taking on tasks they did not want because no one else on the team was doing these tasks. Often, these are the tasks a team fails to recognize and name at the outset. Teachers can help teams identify necessary tasks more comprehensively. The researchers also suggest coaching student teams on communication styles and team dynamics and encouraging teams to hold some of their negotiations by synchronous online chat, so that more voices can be heard.

Assigning students to specific roles in an intentional and purposeful way can help “disrupt the self-perpetuating feedback loop in which students gain skills and experience according to their pre-existing expertise” Fowler and Su stated (p. 317). “Even random assignment of students to roles would disrupt the loop, and instructors could actually counteract it by assigning students intentionally to give students new mastery experiences.” In taking this route, teachers need to gather information about students’ pre-existing skills (via, for example, a survey at the outset), to monitor progress of teams, and to understand that students assigned to unfamiliar tasks may feel high discomfort. This is where, we note, Sanford’s [15] model of readiness can come in handy, to help teachers balance the level of challenge and support they provide.

B. Our own observations

In our study we discovered that despite facing different barriers than the Irish women who were part of our overall sample, this group of female Middle Eastern students was able to overcome the obstacles they encountered in studying engineering abroad. All but one from the entering cohort of eight persisted through to graduation, and the one who left had found her true calling was English and she returned home to become a language teacher. The other seven stuck with engineering, and described feeling well supported despite facing trials, tribulations, and a complex and demanding workload.

Working to understand what these students from the Middle East experienced might help us teach them, and other study abroad students, more effectively. In the following sections, we explore ideas around student support, team formation, and content delivery, giving specific consideration to this sub-set of students and the stories they shared. In doing so, we have sought to support diversity and inclusion in the engineering classroom.

1) Student support

This group identified challenges and forms of support that differed from those described by Irish and international students schooled in Ireland enrolled alongside them. They encountered more trouble with language—having learned

everything they knew about physics and maths in Arabic—but they also had never needed to work or communicate with boys. Their teachers in Ireland, while mostly seen as kind, had little to no understanding of their homelands. They did not seem to understand the students' use of digital devices to look up and translate terms, or the challenge that looking things up presented in following what the teacher was saying; rather, they feared the teachers thought they were goofing off online rather than seeking to understand. When they failed to make a connection to their past learning, they seemed to others to be underprepared, even in cases where they had mastered the material. These students came from very tight-knit families and, being unaccustomed to communicating with such diverse people, seemed to experience more homesickness than others in their course. Their families were far away and visits, even over extended breaks, were not always viable.

They did, however, enjoy and appreciate the support provided by their governments, including scholarships, housing assistance, cultural programs, and help getting oriented and connecting to resources. One participant said this high level of support fostered a bit of resentment from other students, and suggestions that they had it “too easy”. Although this indicated some level of bias from other students, they said they perceived no bias from the Irish and had good experiences communicating with local people, especially taxi drivers, all of whom they described as helpful and friendly. Despite a couple of isolated encounters (a person tugging at a headscarf, for instance), they felt welcome and safe. Back home, they had been told Ireland was a good place for Arabic people to study—better than the US and UK regarding lack of prejudice, and their families had had good experience. They said they had, too.

2) Team formation

As noted earlier, “non-traditional” students, those of minority status, can be at a disadvantage in forming teams. They often find themselves feeling “left over” as mainstream students quickly cluster into working groups for select-your-own team assignments. Although every single participant in this sub-group wanted to team up with Irish and/or English-speaking students, they very often found themselves grouped with others like themselves. Initiating diverse groups was not easy for them. We recommend teachers utilize an array of team-formation practices, at times assigning the groups to maximize diversity while leaving no student isolated as the sole woman or sole minority student in the group, and at other times allowing students to pick their own teams. As indicated by Fowler and Su [1], it is a good idea to monitor student engagement—to observe teams at work and to provide them feedback about the underlying dynamics and any forms of conscious or unconscious bias they see. Teachers also provide valuable models for students, in the way they communicate, interact with people, and make decisions. Teachers can and should demonstrate how to go about communicating, allocating tasks, and making decisions effectively. They can highlight good collaborative practices, e.g., for planning and accountability. The teacher can promote the classroom as a laboratory for learning and help students embrace a growth mindset and a constructivist, collaborative outlook on knowledge creation. Fowler and Su recommend helping students set goals and embrace a mastery orientation, as opposed to performance orientation. Active and peer-to-peer learning pedagogies can help; it is important to note that the more advanced students benefit greatly from teaching and making new connections as they consider how to describe

things [16], and those learning the new material often find it easier to hear from a student than a teacher, as our participants said.

3) Content delivery

The way teachers communicated in the classroom frequently caused stress for the Arabic participants in our study—starting day one. In first year, a participant explained, “*the teachers speak quickly ... we try to focus in it and we take the main point ... When I was in my country, I [studied] these subjects, in my language. ... I understand the calculation things,*” but can’t immediately connect it to the content being discussed at the moment.

A third year student said, “*sometimes, when ... I have to take my phone and search what this word is... I miss everything ... after that*”. Moreover, interpreting handwriting can be hard, and sometimes “*when they start writing on the board, I don't know the words. All letters [run] together. I don't know where they start ... it's like a drawing.*” She tries to see what peers have noted down to help her follow along. It can be a particular challenge when teachers abbreviate or don’t leave much space between words.

This gets us back to the topic of tacit knowledge implied earlier. In many cases, the teachers use frames of reference familiar to local students, but not those from other cultures. Teachers expect all the students have experiences embedded in the Irish curriculum, and sometimes don’t provide background information crucial for running the experiment or completing the assignment. As a result of these interviews, we recommend that teachers enunciate more carefully and check that all students truly understand before moving on.

Related to delivering content, we encourage teachers to show they are approachable, as well as how and when they can be contacted. It is important to consider choice of words, and to answer questions using a variety of terms to help students connect new learning with prior experience. They may have used different terms in school, so it can help to provide a range of examples and word selections. Teachers make assumptions about what comes naturally to people, what is already known. The abbreviations, symbols, graphics, and methods of representation used in the Anglophone world will be new to many international students. It’s a good idea to pose concept questions at the outset of a lesson to check that students have the necessary background, understand core concepts and are connecting back to prior learning. International students may need to use electronic devices to translate a term or ask a friend to help make the connection. Alternately, the teacher could watch for points of confusion, using some form of *muddiest point* activity [17] and address these with the group. In addition, international students mentioned they sometimes need more definition regarding an assignment than home students, who may more readily understand that the teacher is expecting a diagram, for instance, as opposed to a lab report or a planning document.

V. FINAL REMARKS

We have changed the way we form teams, in response to these interviews. We now diversify student teams more purposefully, considering, when possible, an array of factors such as gender, “traditional” versus “non-traditional” status, and past performance and engagement levels. We encourage and create situations for students to work in many different types of teams and with many different people. Here again, we work to ensure no student is isolated as the only female or only

minority student in a group. We also provide some targeted opportunities for self-selection of groups and—when students are new to college—we organize in-class icebreakers to help them get to know others before they form teams. The students in this sub-set felt the males on their teams often raced ahead and discounted or ignored ideas they tried to put forward. They said it helped to have another woman on the team, or someone speaking their own native language, to confer with before proffering ideas to the larger group. They wanted to confirm the idea was strong enough that they could justify and/or argue for it. Yet they also valued diversity.

Overall, we seek to understand Middle Eastern female students' lived experiences, specifically because we believe they encounter different obstacles, stressors, and challenges than students who attended secondary school in Ireland. We are working to identify aspects that we and other educators might be overlooking and to help us all do a better job supporting such students. Our next step will be to interpret all eight women's interviews, a total of 20, using a framework known as 'The Hero's Journey' developed by Joseph Campbell [18] and recently adapted to engineering education research by Nadia Kellam and colleagues [19, 20, 21]. Currently, we are using the Hero's Journey framework to analyze and retell powerful narratives shared with us by a single mother who returned to university after several unsuccessful tries at third-level education and more than a decade working as a barmaid [22]. She not only successfully completed the four-year B.Eng. course but earned top awards and is now enjoying immersion in the engineering workplace. Once our research team develops skills telling her story—to help others understand the challenges a single parent faces when studying engineering—we will work to tell the shared story of these eight brave and inspiring young women who joined our community to study engineering.

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