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Exploring Women's Teamwork Experiences In Engineering Education: A Phenomenological Analysis

Sandra Ireri CRUZ MORENO
Technological University Dublin, Ireland, sandra.i.cruz@mytudublin.ie

Shannon CHANCE
Technological University Dublin, Ireland, shannon.chance@tudublin.ie

Brian BOWE
Technological University Dublin, Ireland, Brian.Bowe@TUDublin.ie

Exploring women's teamwork experiences in engineering education: a phenomenological analysis

S.I. Cruz Moreno [1]
Technological University Dublin
Dublin, Ireland
ORCID 0000-0002-2573-1323

S. Chance
Technological University Dublin
Dublin, Ireland
ORCID 0000-0001-5598-7488

B. Bowe
Technological University Dublin
Dublin, Ireland
ORCID 0000-0002-4907-1913

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ABSTRACT

Teamwork, project or problem based learning, and other collaborative learning strategies are often presented as approaches that benefit women and other minorities during their studies in Science and Engineering fields of education. This is based on the assumption that underrepresented groups will respond positively to the social integration and cooperation encouraged by these learning methods. However, research also shows that gendered stereotypical presuppositions about attributes and interests can influence the performance of team members and the tasks developed, potentially providing opportunities to sexism, racism, and other exclusionary social behaviours.

In this context, this paper describes a piece of an on-going research project that examines the experiences of women studying engineering and the extent to which

[1] *Corresponding Author*

S. Cruz

sandra.i.cruz@mytudublin.ie

collaborative learning methods have supported their education. The study utilizes phenomenology as the primary methodological framework for data collection and analysis. The paper provides a description of the methodology employed, drawing on a subset of data from 22 college students who were interviewed.

Insights gained from narratives on group work by women studying engineering at a university in Ireland offer valuable perspectives on their lived experiences, allowing for a reassessment of the effectiveness of certain collaborative learning practices. Furthermore, as phenomenological research has become increasingly popular in Engineering Education Research (EER), this paper contributes to the refinement of methodologies for EER scholarship.

1. INTRODUCTION

1.1 Problem statement

According to the most up-to-date global data in higher education, participation rates of women in tertiary education degrees were increasing between 2016 and 2019; however, the gender gap of students enrolling in and graduating from fields in information and communications technology (ICT), Engineering and Manufacturing have remained almost unchanged (OECD 2021; World Economic Forum 2022). Additionally, while in 2019 more than half of all tertiary education graduates were female, the proportion of women graduating in STEM subjects dropped to 41% (UNESCO 2022). This indicates that although more women have been pursuing higher education, they are still significantly underrepresented in STEM fields.

Progressing women in engineering has been promoted for at least three reasons: (1) as means to support gender equality and social justice (Clavero and Galligan 2021; Rosa and Clavero 2022); (2) to tackle the shortage of engineers by attracting new profiles into the workforce (Beede et al. 2011; Moloney and Ahern 2022); (3) to ensure better results in engineering solutions, by increasing diversity in race and gender (Hersh 2000; Tannenbaum et al. 2019). In any case, research findings keep indicating difficulties in achieving wide student diversity in engineering, and this has encouraged pedagogical changes within engineering education (Berge, Silfver, and Danielsson 2019).

1.2 Existing research and research gap

Teamwork, project- or problem-based learning (PBL) and other collaborative learning strategies have been some of the teaching approaches implemented to support students pursuing degrees in STEM, particularly students who are women or from underrepresented minority (URM) groups (Du and Kolmos 2009; Du et al. 2020; Kolmos and de Graaff 2014). Nonetheless, there is also research showing the roles assigned to each member of the team and their performance might be influenced by gendered stereotypical assumptions (Beddoes and Panther 2018; Hirshfield 2018; Meadows and Sekaquaptewa 2013). Groupwork can provide opportunities for discriminatory behaviour such as sexism and racism, influenced by prejudices about minorities. These behaviours can lead to unequal task allocation and acceptance, and lead to further exclusion of URM individuals who might struggle to fully participate in the teams (Fowler and Su 2018; Okudan Kremer 2003; Wolfe and Powell 2009).

Even though it is generally agreed that collaborative learning supports students in their academic pathways in engineering, there is a need to better understand how engineering students undertake collaboration in a project team (Du et al. 2020).

Moreover, the lived experiences of women in teamwork may differ from those of men. Therefore, further research is needed to reveal the challenges women face in groupwork; it would be helpful to identify best practices for creating supportive learning environments for women and others from URM groups. By researching this, we can contribute to increased persistence and enhanced graduation rates of women and URMs in undergraduate engineering programs, ultimately leading to a more diverse and inclusive engineering workforce.

1.3 Research questions and aim of the paper

The on-going research project is framed by the following research questions:

1. What challenges due to gender dynamics have the women in our sample group faced in teamwork throughout engineering courses at university?
2. What strategies have these women developed to deal with these challenges?

This paper focuses solely on the first question and uses phenomenology as main methodology. The aim of this article is not only to explore insights on experiences of women in teamwork during their engineering courses, but also to demonstrate the practical application of phenomenological methodology as a contribution to the growing body of Engineering Education Research (EER) scholarship that uses qualitative research methods.

2. COLLABORATIVE LEARNING IN ENGINEERING EDUCATION

2.1 Team based learning pedagogies

Research has identified that project- and problem-based learning (PBL) have benefits in engineering students such as: (1) promoting deep approaches of learning instead of superficial learning, (2) improving active learning, (3) developing self-directed learning capability, (4) increasing the consideration of interdisciplinary knowledge and skills, and (5) developing management, collaboration, and communication skills, among others (Du and Kolmos 2009). Furthermore, PBL has also been shown to increase self-confidence and sense of belonging (Kolmos and de Graaff 2014; Du et al. 2020). A literature review of research on engineering students' perceptions of generic competence development in PBL, conducted by Boelt et al., (2022), found positive effects of teamwork.

However, PBL, as any other learning theory, can be transformative when it is contextualized, in terms of ideology, culture, power and race-class-gender differences (Mezirow 2018). Learning theories on teamworking suggest that in order for people to find a reason to work together, they must perceive a sense of identity and a need of a common purpose (Bates 2019). From the point of view of social psychology and according to Fiske (1998), the core features people use to make social judgment are gender, age and ethnicity. Based on those dimensions, individuals tend to build a continuum of "categories" to establish a variety of groups of people, who they perceive they can relate to or not. Such definitions also might add social pressure, if a person worries about either fulfilling the stereotype, or overcoming it when it feels like a stigma (Fiske 2010).

2.2 Gender and teamwork

Du and Kolmos (2009) have documented that project work in teams and collaborative ways of learning in engineering education help female students feel highly motivated and perceive that the technical part is less difficult to handle through peer-to-peer

learning compared to individual learning. However, for women students in engineering, teamwork often means being the only female in the group, a condition that demands adjusting to a masculine culture (Charity-Leeke 2012; Dryburgh 1999). Moreover, being a woman in engineering and also part of a minority group could lead to feelings of intimidation due to having multiple underrepresented statuses; this condition might affect one's performance in teamwork, because it can foster the perception of needing to work harder to prove oneself (Dancy et al. 2020).

While gender is an important lens through which to analyse power dynamics and social relations, it is crucial to avoid essentializing and homogenizing women's experiences. A narrow focus on gender oversimplifies the causes of inequality in STEM (Alegria and Branch 2015)

3.3 Conceptual framework

The theoretical framework of the research is based in Schutz's social phenomenology (Schutz 1972; 1967). From Schutz's perspective, the analysis of social action needs to consider the subjective meaning that the actor gives to their own actions, including the inner motive of action. The daily life experience is essential to doing so. However, the discernment of the meaningful systems requires not only the observation of the actor's present experiences, but also an exploration of their past and the internally pre-projected future (Tada 2019).

It is appropriate to mention these theoretical premises because the interpretative work carried out with the data collected rests upon them. Four concepts of Schutz's theory are key to this research: stock of knowledge, life-world, intentionality, and projecting:

- *Stock of knowledge* refers to the information that people know and share with each other that, on the one hand, is created through social interactions and, on the other hand, helps us make sense of (and navigate) the world around us (Schutz 1967, 13). This information is accessible to everyone and can be adapted as an individual faces new challenges or encounters differences that their existing knowledge does not address.
- The concept of *life-world* denotes the world of immediate experience common to all of us, not the private world of any individual (Vargas 2020). It is the daily reality presented to groups of individuals as a shared world (Heiskala 2011).
- The concept of *intentionality* suggests that meaning in a personal experience is constructed by reflecting on past events and through relations with others (Heiskala 2011; Tada 2019).
- Finally, the concept of *projecting* consists in the anticipation of the future outcome of an action, based upon the knowledge at a hand at the time of projecting, that motivates actor's action (Schutz 1967, 20; Tada 2019).

3. METHODOLOGY

3.1 Research design

The use of phenomenology as the starting point for the research serves two purposes for this project: the first is to understand the women students' experiences studying engineering degrees. The second is to draw attention to the evolution in students' experiences along the engineering program that redefine their meaningful systems and, with them, their identities, behaviours, and plans in engineering. The phenomenological interviews informing this paper included a longitudinal component that supports analysis of such evolution.

3.2 Sampling and data collection

The subset of interviews used for this piece of research is part of a larger project initiated in 2014 by the research team (S. Chance and Bowe 2015; S. M. Chance, Williams, and Direito 2021; S. Chance and Williams 2016). For this paper, 42 interviews were used; they were conducted with 22 female engineering students at Technological University Dublin (TUD) in Ireland. The longitudinal dataset comprises students from a variety of sociodemographic backgrounds, an aspect that enables a diverse sample for an intersectional analysis on women and URMs. In Table 1, general information about the participants is shown.

Regarding the recruitment process, all the participants for the first cohort of interviews were self-selected. The inclusion criteria to invite them were two, the student was: (1) a woman[2]; (2) had started the engineering undergraduate program in TUD in the autumn of 2014. The research team conducted follow-up conversations with some of the participants (i.e., the second and third interview indicated in Table 1).

Table 1. Participants in interviews

No	ID	Country of birth	Years in Ireland*	Year in Major*	Field of interest in engineering*	Second interview	Third interview
1	IR01.1	Ireland	Birth	First	Structural or mechanical		
2	IR02.1	Ireland	Birth	First	Structural or manufacturing and design	Yes	
3	IR03.1	Ireland	Birth	First	Mechanical engineering		
4	IR04.1	Ireland	Birth	First	Mechanical engineering		
5	IR05.1	Ireland	Birth	First	Mechanical engineering		
6	IR06.1	Ireland	Birth	First	Indecisive, maybe electrical		
7	IR07.1	Ireland	Birth	First	Environmental engineering	Yes	Yes
8	IR08.1	Ireland	Birth	First	Indecisive of staying in engineering		
9	IR09.1	Ireland	Birth	Second	Electrical and electronics		
10	ME01.1	Oman	2	Second	Manufacturing and design engineering	Yes	Yes
11	ME02.1	Oman	3	First	Architectural engineering/civil engineering	Yes	Yes
12	ME03.1	Oman	1	First	Computer and communication engineering	Yes	Yes
13	ME04.1	Oman	3	First	Civil engineering	Yes	
14	ME05.1	Kuwait		First	Mechanical engineering	Yes	Yes
15	ME06.1	Kuwait	5	First	Mechanical engineering	Yes	
17	ME07.1	Oman	3	First	Civil engineering	Yes	Yes
17	ME08.1	Kuwait	2	Second	No interest in engineering		
18	FO08.1	Malaysia	2	First	Computer engineering		
19	FO09.1	USA	5	Second	Computer engineering	Yes	
20	FO10.1	India	6	First	Mechanical Engineering	Yes	Yes
21	FO11.1	Philippines	12	First	Mechanical Engineering / aeronautical engineering	Yes	
22	FO12.1	Philippines	6	First	Mechanical Engineering	Yes	

* At the time of the first interview.

Interviews were conducted by the second author, Professor Shannon Chance, using a phenomenological approach. They took the form of an open conversation around students' first experiences in studying engineering, the pleasant situations and the

[2] Note that the first inclusion criterion was embedded with assumptions: all students in the cohort presenting as female and presumably designated female at birth were invited to attend interviews. The participant's gender identity or gender expression was never explicitly asked, therefore, insights from the students can only be analysed with a binary approach of gender.

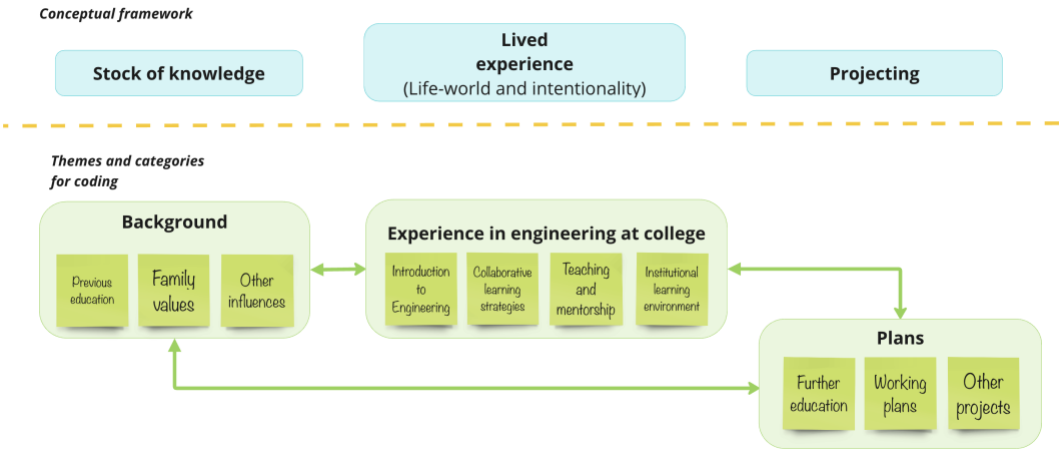
more challenging, thoughts on group-work, and feelings regarding the predominance of men in the classes. Students described and explained not only their experiences since they entered the university, but also shared stories about their families, friends, jobs and/or plans.

3.3 Data analysis methods

Following standard guidelines for Interpretative Phenomenological Analysis (IPA) (Alase 2017; Noon 2018), the initial step for data analysis was data immersion, which involved the lead author reading the transcripts while listening to the audio recordings of the interviews.

The second step in the data analysis was to code the data (Saldaña 2013). Three themes were determined beforehand by the lead author (deductive coding), based on the key concepts of the theoretical framework explained above. These were: (1) Background, (2) Experience in Engineering at college, and (3) Plans. Within each of these themes, an inductive coding was performed and meaning units were grouped as categories identifying patterns. Figure 1 shows the adaptation of the conceptual framework into coding themes and categories (due to space limitations here, not all categories are shown).

Figure 1. Coding themes and categories based on conceptual framework.



The interpretation of "meaning units" is an important step in the analysis process; it involves finding relationships between codes to create more profound and coherent units of analysis (Moustakas 1994). Given the scope of this paper, the focus of the analysis is centred only in the category of “collaborative learning strategies”.

After analysing and coding the transcripts two categories of “meaning units” of the students’ experience were distilled, regarding: (1) cultural practices in study groups, and (2) emotional aspects of teamwork. The first one comprises aspects of the group composition, the decision making processes, establishment of roles and norms, teaching practices and learning accomplishments. The second one includes the interpretation of enjoyable and frustrating experiences, cooperation and conflict, as well as feelings regarding sense of belonging and self-confidence.

4. DISCUSSION AND RESULTS

Phenomenological methodology aims to gain understanding not only on the participants’ experiences, but also on the meaning attributed to them. The coding

system being used has allowed us to observe, on one hand, how students' life stories influence their experiences in engineering. This helps us make connections between their past and *stock of knowledge*, and their meaningful experiences in engineering courses. Additionally, understanding the students' projects and plans has helped us comprehend their decision-making processes (intentionality) and the subjective meaning they attribute to their daily experiences in engineering studies. This approach establishes a temporal context in which the phenomenon was experienced by the participants and enables us to track the evolution of its meaning.

Regarding the first research question (about the gender-based challenges that the sampled women have faced in teamwork), results are reported in the stages of a simplified PBL cycle: (a) Planning; (b) Execution; (c) Assessment.

4.1 Attitudes towards teamwork

Participants reported differing attitudes toward teamwork. Those who were content working in groups stated that learning is easier because people can help each other, share ideas, and draw on a variety of knowledge to develop the project. Furthermore, comparing results with those of other groups helped students to understand how problems can be solved from different perspectives.

In contrast, another subset of students reported finding teamwork challenging, mainly due to the following reasons: (1) not everyone being willing to cooperate; (2) having preference for more independent learning; (3) groups being too large to manage learning; and (4) lack of prior experience with group projects at the college level.

4.2 Planning the team project

Regarding their experiences in the planning phase, interviewees noted the advantages and disadvantages of selecting their team themselves or being assigned to groups by the lecturer. Choosing their own group facilitates students' interaction because they know (and trust) each other and recognize individual strengths. Often, when students are allowed to choose their teammates, they select those who are seated next to them because they are already friends or, at least, acquaintances from the course. Nevertheless, this familiarity can also result in inequitable workload, when students want to be accepted by their peers.

Regarding experiences with group designation, students felt frustrated when they were unable to choose their own group and ended up with teammates who were not as committed as they would have desired. Another challenging aspect of being assigned to groups is the diversity in the cultural background and language. Students noted that it was a positive experience to have people from different countries and regions, so they could learn a broader range of viewpoints. This was also beneficial in re-examining certain stereotypes. However, not speaking the same language as the majority in the group sometimes made students feel excluded. Narratives on this were mentioned not only by international students who struggled to communicate in English, but also by Irish students who were in teams where other members were speaking in their own mother tongue.

An additional topic in the planning stage of the project was the assignment of roles and the agreement on rules. Students' experiences demonstrate that being the project manager is a role more often assigned rather than chosen, as it carries more pressure and work. Three different female students described this experience:

- *They all kind of looked at me and it was like, "Yeah, you're doing that"*.

- *And they all pointed at me. Didn't even say anything. They all pointed at me. And I was like "Fine".*
- *They just told me, "You be the Project Manager." So I just said, "Yes." I don't have the chance to say yes, but I don't mind because I'm okay at that.*

4.3 Execution of the project

The experiences related to the execution of the project describe the willingness of women students to assist other team members in completing tasks, particularly in the last-minute work. Students expressed frustration when attempting to motivate their teammates, as well as with the work itself, due to difficulty in finding solutions to emerging problems. For students with the role of project manager, having a set of rules was found helpful in establishing penalties for those who failed to show up or submit their assignments, without feeling like a whistle-blower or being too harsh.

Finally, some gender-related concerns around teamwork were disclosed by the interviewees: (1) assumption that they could be relegated away from decision-making on the project; (2) fear of shortage of technical knowledge; (3) expectations of solidarity between women; and (4) prenotions of women being more proactive than men at performing tasks for the teamwork.

4.4 Project assessment

The assessment stage comprises both learning accomplishments and the grades obtained at the end of the project. Overall, students recognized they were learning a lot from their peers and through having hands-on projects.

The perception of the relevance of the grades varied greatly among the participants. Some international students became very stressed out by the marks the team received and took on more work than had been agreed upon at the beginning to ensure the project was completed. In these cases, they were distressed at having the same grade as other members who did not work as much as they did.

Other students were satisfied with their project results, not because of the grades they received, but rather because of the effort they put in, the experience they gained, the mistakes they learnt from, and the fun they had building new friendships.

5. CONCLUSIONS

This paper aimed to reflect on challenges that women face in groupwork along engineering courses through phenomenological analysis. The women's lived experiences of engineering in team projects reflect attitudes and beliefs they have interiorized throughout their lives as part of their culture, family values and previous education experiences (stock of knowledge), which are the foundation in undertaking teamwork. The narrative of the interactions with team members shows not only aspects of the self-image and self-confidence of the sampled women students, but also the social dynamics they face with their teammates.

The significance of investigating gender-based interactions in close learning environments and the utilization of collaborative learning strategies is underscored by this analysis. By providing a detailed account of the research process, this paper can serve as a model for future phenomenological research in EER.

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