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Gender Complexity and Experience of Women Undergraduate Students within the Engineering Domain

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Abstract: Despite continuous efforts for reducing gender inequality in Science, Technology, Engineering, Mathematics (STEM), engineering still steadfastly remains one of the least equitable fields in Australian universities. There has been an increasing growth of international scholarship on women's underrepresentation in engineering; nevertheless, research on understanding contributing factors to the Australian women students' participation in engineering is relatively underdeveloped. To address this knowledge gap, we examine the experience of women undergraduate students and explore influential factors that contribute to the complexity of pursuing engineering. Applying a qualitative approach, we conducted 16 interviews with women undergraduate students enrolled across five engineering courses at Macquarie University, Australia. The results of the thematic analysis indicate that women students often have a supporting network of relationships and view themselves as intellectually fit to study engineering. However, they have been facing several interrelated obstacles that negatively impact their experiences and persistence in engineering. Findings show that gendered perceptions around femininity and masculinity appear to be the origin of gender stereotypes surrounding engineering identity. These not only negatively impact women students' experiences within the bound of university but also create systemic barriers in the future workplace environment and opportunities. These (mis)perceptions have actively and passively made women students feel out of place, doubt their abilities and feel alienated. We offer suggestions to shift engineering identity outside the dominant masculine construct towards 'co-construct' and 'co-enact'. This will create windows of opportunities to move towards gender equality in engineering.

Keywords: women in engineering; gender equality; underrepresentation of women; gendered perceptions; engineering identity

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1. Introduction

In the past decade, we have witnessed evolving policies and institutional efforts for promoting gender equality, addressing gender bias and reducing gender gap in different areas, including Science, Technology, Engineering and Mathematics (STEM) [1,2]. Acting on this, the Australian government has committed to improving women's and girls' participation, recruitment and engagement in STEM education and ecosystems. The National Innovation and Science Agenda (NISA), the Women in STEM and Entrepreneurship program (WiSE) and the Science in Australia Gender Equality program (SAGE) are examples of programs initiated to inform national strategy to attract, retain and support women and gender diverse individuals in STEM and develop action plans for promoting gender equity [3]. The Australian Academy of Science and the Australian Academy of Technology and Engineering have recently developed a "Women in STEM Decadal Plan" to attract, retain and progress women and girls in STEM education and careers. The plan aims at

providing an equitable education system in which girls and women are enabled and encouraged to study STEM courses and significantly to increase the number of their enrolments within tertiary education by 2030 [4].

Despite these continuous efforts for promoting women in STEM education, we have not yet reached gender equality [5,6]. In Australia, women's participation in higher education has increased in the past decade, however only about 30% of STEM qualifications are held by women [7], indicating the persistence of gender imbalance in these fields. The gap is much wider in the engineering field, which has been remarked as the least gender equitable among the STEM fields, with women accounting for only 13% of the Australian engineering workforce [7–9]. The engineering profession in Australia has traditionally attracted few women [10] and it still steadfastly remains one of the most male dominated fields within the confines of Australian universities with only 10% of women students graduated from higher education across engineering courses [4,11]. While high demand for qualified engineers in Australia is an economic imperative, the number of women in vocational training (less than one in ten) and at universities (about one in six), shows tremendous disparity [12,13]. This not only signals a narrow talent pool and lack of diverse perspectives in tackling engineering challenges, but may lead to the exclusion of women from designing the future.

This article is impelled by the dearth of women in engineering domain. The underrepresentation of women in engineering is an important topic since it traverses equality, diversity, social construct in the domain, roles and identities in both tertiary education and further, into industry. Thus, we aim at understanding the experience of women undergraduate students and identifying influential factors that contribute to the complexity of pursuing engineering. There is a significant body of literature that refers to the historical inequalities in STEM as the "leaky pipeline" [14] (and associating the engineering discipline with a cluster of traits often attributed to men, such as being "agentic", "instrumental" and "analytical" [15]), referring to the decline in the number of women even before graduation and job entry. Nevertheless, studies have pointed out that enabling women's and girls' participation in engineering leads to harnessing an untapped talent pool; and recruiting and retaining them expands the existing intellectual capital for future innovation while encouraging and enhancing an inclusive cultural environment [8,16]. Recent studies and reports on practices for promoting women and girls in STEM [3,17] highlight the need for conducting more research to understand contributing factors to women's participation in engineering specific to the Australian context. The current engineering enrolment statistic clearly defines the problem space in terms of numbers; however, further analysis is required to understand what shapes this current model. This article addresses this gap by contributing to improved understanding of how the tertiary experience of women undergraduate students influences their pathways in engineering domain. Understanding the gap is vital in changing the future engineering landscape and attitudes with regard to gender equity at university.

2. Literature Review

Despite four decades' attempts at highlighting the gender gap [14,18,19] and explaining the attrition of women through the metaphor of the "leaky pipeline" [20,21] and through the boundary model [22] women are still underrepresented in STEM fields, particularly in engineering. Our treatment in reviewing the existing literature is driven by the need of this study, to engage with the research on women's under-representation in engineering as we aim to understand the complex social underpinnings of the experiences women undergraduate students face in this field.

Reviewing the existing literature uncovers obstacles women in engineering face in a university setting, from lack of role models to systemic bias. In a revisiting of women under-representation in STEM Australia, studies found that barriers women faced in these fields still persist after two decades [23,24]. This includes the dearth of role models and a lack of career and academic pathway advisers and inadequate support from the education

network. Recent studies emphasise the importance of social capital, including networks of influential relationships and cultural groups (e.g., family, peers, teachers, advisers) on women's experience and engagement in engineering programs [17,24,25].

Systemic barriers in the Australian higher education, particularly in engineering, have led to the experience of gender inequality [8], impacting women's and girls' education trajectories and limiting their career opportunities. Even though the effect of individual interest and aptitude was previously perceived as the reason for the lower number of women in STEM fields, numerous studies identify social structure and education culture as contributing factors to the continuing underrepresentation of women [14,26–28].

Feminist scholars draw attention to the dynamic relations embedded in socio-cultural structure and the construction of gender roles and identities [22]. Accordingly, socio-cultural and institutional forces, consist of beliefs system that prescribe and proscribe divergent gendered values towards masculinity and femininity. Through a gender socialization process, individuals learn to act and behave according to socio-cultural expectations and develop interests congruent with their genders. This system encourages fitting in and discourages deviation from gendered perceptions. The construct of professional engineering reinforces such gendered values [14,22] and has created systemic barriers, such as negative stereotype, bias and discrimination, and made women feel out of place [29–32].

Engineering, regarded as a primarily male discipline [33], is incongruent with stereotypes around "normal" feminine role and lifestyle [3,34]. The widely shared assumptions and stereotypes attached to engineering imply a masculine image and norms; a cluster of traits and values that reflect competitiveness, physical strengths, solitary practices, technical ability, all of which are socially desirable for and associated with men rather than women [15,35,36]. A common and recurring stereotypical envisioning of an engineer is someone who wears labourer's clothing and a hard hat and 'fixes things', e.g., electronics and roads [37–40]. These cultural stereotypes that influence and shape engineering identity are replicated within the environment and education system; and work as gatekeepers that deter women's and girls' pursuit of engineering [41–44].

Moreover, the perpetuation of such stereotype around engineering identity has created an "unwelcoming environment" for women and marginalized groups, causing a mismatch between women's and girls' self-concepts and engineering identity [24,45–48]. Weston et al. [49] found that students view lack of fit and lack of support as systemic issues women have faced in STEM education culture. In another approach, Matusovich et al. [50] showed that, indeed, an increasing number of women, compared to men, experienced a "lack of connection between their engineering-related values and sense of self (low attainment values)" illustrating a key differential in terms of gender-based identity, value, role and worth in engineering. 'Gender socialisation' and 'social identity' perspectives, contextual cues or as Oyserman et al. [51] describe "features in the environment" influence identity by triggering people's self-view based on their perceptions of relevance to a specific social identity [52]. Accordingly, women and girls who are actively seeking engineering as part of their social identity may perceive engineering-related values conflicting and incompatible [53] and consequently find it difficult to socially fit in. Therefore, students who did not fit or identify with engineering are more likely to leave this field [49,54].

Despite the rapid growth of international scholarship on women underrepresentation in STEM and particularly engineering, research on understanding enablers and barriers to the Australian women students' participation with a focus on engineering discipline is still relatively underdeveloped [3,17,55–57]. This article, thus, attempt to address this gap through understanding contributing factors to the experience of women engineering students within the context of an Australian university.

3. Materials and Methods

The main research question of this study is "what is the experience of women undergraduate students enrolled in an engineering program?". To answer this question the

article aims at understanding contributing factors to their experience prior to and during their tertiary study, by addressing these following sub-questions:

- What barriers have women undergraduate students been facing prior and during their tertiary education in engineering?
- What motivating factors have women undergraduate students had to pursue engineering?

We applied a qualitative approach as it seeks a rich in-depth knowledge "through describing and interpreting a subject/phenomenon as it occurs in a socio-cultural context" [58]. This approach applies a range of methods such as interview and personal experience to cultural interactions to better understand the subject [59] and allows themes to be generated [60]. To answer the main question, we conducted a case study within the Australian context at Macquarie university, where the school of Engineering is a decade established school with a low number of women undergraduate students enrolled in engineering courses (This is explained further in the following section). Qualitative researchers suggest case study as an appropriate method when the purpose is to develop knowledge, explore and understand a social phenomenon within a specific group [61].

3.1. Context

This article presents a case study of women engineering students at Macquarie University, Faculty of Science and Engineering, Australia. The engineering school offers five majors in engineering programs: including electrical/electronics, mechanical, civil, mechatronics and software engineering. The proximity to a business park (Macquarie Park), which is colloquially known in the engineering industry as a "Technology Park" is a rare opportunity for a university in Australia to be immersed within such an environment. This factor is pertinent in terms of student and faculty reach-back into the engineering community. In addition, the age and history of the engineering school, presents a unique opportunity to examine a decade young school in the process of burgeoning discipline development, evolution and recognition within the tertiary arena. To this end, Macquarie University joined the Science in Australia Gender Equity (SAGE) pilot program to support the attraction, retention and promotion of women in STEM. However, the number of women students enrolled in engineering courses indicates a significant gender imbalance in this field. A case in point is the 2021 engineering enrolment at Macquarie University, whereby less than 9% of total cohort of undergraduate students (34 women out of a total cohort of 407 students) were enrolled in a first-year engineering course [62].

3.2. Participants

This research included the participation of 16 women undergraduate students enrolled across all five engineering majors at Macquarie University Participants age ranged from 18 to 22 years old and all were enrolled in 2021 and represented various levels of degree completion including, six students at the early stage of their study, five in the middle and five at the end of their engineering undergraduate degree.

Research was activated by querying the Macquarie University Enrolment Database, supplied by the School of Engineering [62], which allowed informing women undergraduate enrolled across all five majors about the research and asking their voluntary participation. Then, a combination of convenience and snowball sampling strategies was used to locate participants by asking them to introduce other peers studying engineering in the school. This was an effective sampling technique as it enabled accessing participants who volunteered to share their experiences [63].

3.3. Methods and Procedures

We used semi-structured interviews to gather information and to gain deeper knowledge of women engineering student's lived experiences. The primary researcher (first author) conducted face-to-face interviews, which allowed additional probes and follow ups as needed. Participants were encouraged to share their major and education background, family, college and university experiences. Each interview took between half-an-hour and

an hour and took place at Macquarie University, in a research, teaching, laboratory and office space allocated to engineering students, with only the researcher and interviewee present. All interviews were recorded with the consent of participants, and then transcribed and de-identified to ensure confidentiality and anonymity of participants. The experiences, stories and opinions of women undergraduate students are the core data of this article, which will be shared in the form of quotations. The low numbers of women enrolled at the faculty could potentially allow for easy identification of participants. To minimize the risk, quotes are not assigned to names, majors or year of study rather assigned only by number, i.e., Participant Number 01 (PN01).

Participants were posed questions at three anchor points. The first anchor aimed at understanding women students' pre-university experience, such as influential factors on choosing engineering. The pertinent questions were reflective and encouraged "look back" approach. For example, when you decided to choose engineering and why? The second anchor point enquired about the current position of students. Questions were designed to invite the students to "look within" at their current social process and experience to explore feelings, current discourse and remark on their own interpretation of particular constructs, such as working with male peers and examining social systems and construct within engineering. The last set of questions, tend to examine the women students' preparedness to enter the engineering industry, focusing on future change potential, such as their perceptions of the existing opportunities and obstacles.

3.4. Data Analysis

The collected data were analysed using thematic analysis, which allows identifying patterns through analysing participants' experiences without being confined with theoretical commitments [64]. This involves several stages from 'immersion' and 'structuring' the data to 'categorisation', 'searching for themes', and 'sense making' [65]. To generate themes out of the gathered information, the interview transcripts were read repeatedly by the primary researcher and discussed between all researchers. Following systemic procedures and flexible thinking allowed us to be exploratory and adaptable to any possibilities that emerge during the analysis without controlling the situation or the participants. This led to the identification of patterns and emergence of initial items pertinent to the research questions. In the next step, quotes and phrases relevant to the research question were identified and highlighted. Then, these identified patterns and themes were refined and connected for sense making, drawing discussion and conclusion.

4. Findings

This study harnessed an opportunity to include varied views. Each participant's response is a unique element in the body of this work and drives a better understanding of influential factors in the experience of women engineering students. In explaining their experiences as women undergraduate students in engineering, participants reflected on two key factors that the literature review describes as influential and impediment [8,14,23,25,36]. This section addresses the research question by identifying key contributing factors, motivators and barriers, that positively and negatively impacted the experience of the participants in engineering. Analysing the curated data has led to the identification of four themes and two sub-themes named in Figure 1, which are described below with excerpts from participants.

4.1. Motivating Factors

In talking about their motivations to pursue engineering, participants elucidated those influencing factors which actively or passively encouraged them to pursue engineering. Motivating factors origins are distinguished as network of relationships and participants' self-concept intellectually.

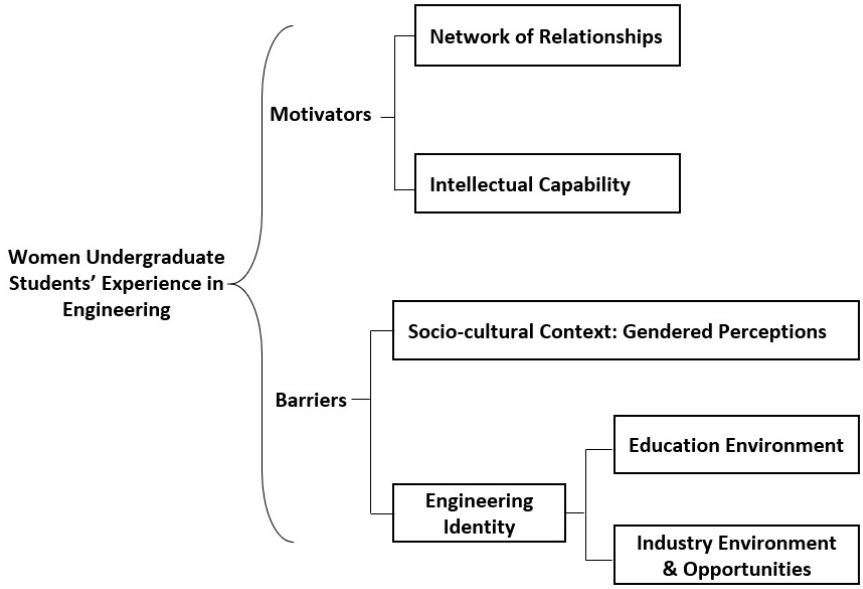

Figure 1. A summary of contributing factors to the experience of women engineering students.

4.1.1. Network of Relationships

Several of the participants described family member(s), e.g., a parent, partner, as well as friend and teacher, who were interested in or worked in STEM fields, as those who supported and encouraged them to pursue engineering. This in turn, offered respondents an understanding of how to identify an engineer, what studying engineering entailed and furthermore, provided a definitive understanding of a career map to aspire toward. Decoding the complexities of what engineering looks like assists in the imagining of the role for the student. A family legacy contributes to this concept and offers encouragement in the form of suggestion, support and infrastructure to know what to expect as an engineer . . . "so I knew what to expect".

There is also implied respect for the profession in that it is identified as a known, acceptable career path given the legacy. This reduces fear of the unknown degree or career path trajectory. A participant explained that initial exposure to engineering as a career option came from experiencing the subject matter through her partner's coursework:

> *"My partner was studying engineering and I really liked what he was doing so stopped my studies and started engineering".* PN06

The shared space with her partner as a pseudo-mentor also facilitated an easier transition into engineering for the student. Another participant nominated a teacher at high school as a significant influencing agent to study engineering, whereby declaring that:

> *"I had one teacher that explained where my interest could go, as a profession and encouraged me to study engineering".* PN10

The student's expressed interest, intertwined with her abilities–specifically maths and physics–served as a primary driver for the suggestion. Participants who had similar experiences described their teacher as someone who was either a past student of engineering, was a maths or physics teacher, and/or previously attended STEM related education programs.

> *"There was an engineer (male) that came to my school. The way he spoke about engineering and what it looked like . . . I was like – "that's definitely for me!". I have always loved problem solving".* PN14

One could surmise that with either one of the nominated teacher qualifications, enabled the potential to explore engineering as a career opportunity for the students. Besides the influence of school teachers, participants highlighted the influence of building rapport and a network of friends interested in studying engineering. It created an alliance and

encouraged pursuit of studying engineering. Another participant, reported being buoyed in her choice also by her social network:

"Friends around me (were) also looking into engineering (as a career option)". PN02

4.1.2. Intellectual Capability

The majority of the participants referred to themselves as having the "right fit" to meet the intellectual skills of an engineer. They felt intellectually prepared and well suited to fit the archetypical engineering stereotype - maths, physics and problem-solving recognition and excellence. One participant described not only excelling at problem solving, but also of appreciating the idea of making positive changes on a larger scale. The participants maintained that their engineering perceptions came from family, friends, STEM related information presented at school and/or an advocating teacher, hence one participant describing that:

"I felt really prepared to study engineering, I was good at maths and always helping to solve problems". PN16

In addition to the recognition of her maths ability at secondary school, another participant expressed her eagerness to be attached to a domain that was both identified in the community to be intelligent and acknowledged socially as a respectable career choice:

" . . . I liked maths and wanted to study a smart subject". PN13

4.2. Barriers

Collating participants response on influential factors on their experiences, a set of themes emerged indicating obstacles they have encountered. These barriers have actively or passively made them feel out of place, doubt their abilities and be alienated. Evaluating factors that negatively impacted the women students' experience led to the emergence of two interrelated sub-themes: the gendered perceptions within the broader socio-cultural context and engineering identity, which are explained below.

4.2.1. Gendered Perceptions within Socio-Cultural Context

Findings indicate that gendered perceptions significantly influenced women students on the cusp of deciding to study engineering and during their time at university. Further conversation led to the responses from participants pertaining to their concerns around the underrepresentation of women in a male-dominated field.

One participant described her experience around perceptions of how women are identified in general. She spoke of a traditional model of how women are identified and differentiated, with consequent expectations, from the majority cohort. Instances were cited of the dominant cohort stepping in to lift, move, wield physical power and generally take responsibility for the heavier workload in engineering. There was an adherence to a stereotypical male identity which confounded the participant. She reiterated this perception from her experience:

"I think there's a perception that women can't do the hands-on work at uni. We're supposed to be "soft and elegant" . . . it surprises me that the (younger) guys still have that perception at uni". PN11

Perceptions garnered from a particular respondent centred around the premise of the acceptance of a male gaze upon engineering. She expressed her newfound and disappointing reality studying engineering at university as:

"The social standards are that men are the engineers and women are not". PN03

Another participant responding to gendered perceptions studying engineering discussed apprehension around the concept of studying engineering as a woman:

" . . . My dad kind of expressed concern about me being around all men or boys..." PN07

Another participant commented on particularly discouraging, gendered comments received from her high school career counsellor, fuelling concerns regarding the course:

> *" . . . I come from an all-girls school and I remember when we talked about College she (the school counselor) asked me if I am sure about . . . engineering because 'it's for men'".* PN04 (In order to protect the anonymity of the participant, we removed the major from the quote.)

Participants also responded with their own internal doubts about their 'suitability', which contributed negatively towards the decision to study engineering. Whilst a student had fostered an interest and was focused on studying engineering for reasons similar to the majority of participants (intellectual capability, e.g., in maths), the under confidence experienced was significant enough to doubt her choice. A participant remarked that compared to her male peers, she felt:

> *" . . . I felt a lot of self-doubt that I could make it in an Engineering course . . . can I work and study in a male dominated space".* PN04

The internalised discourse of not being skilled enough to study engineering was indicated in the reflections of other students. The participants similarly remarked on their concern regarding not only their ability, but whether they were taught all the relevant technical skills that may be transcribed and utilised in an engineering degree.

Additionally, whilst most participants who declared an inherent confidence and knowledge that they are skilled, prepared and qualified to study engineering, a few participants stated they felt uncertainty and a distinct lack of confidence preceding the decision to enrol in engineering. The participants accordingly sought validation from elsewhere to verify that their inherent concerns were legitimate *" . . . am I smart enough . . . can I manage the study load for engineering*".

4.2.2. Engineering Identity

Gendered roles were also described as being based upon an inherited role model conforming to the dominant culture. The participants expressed the advantage this appeared to have on the levels of confidence and role expectations of their male counterparts as the dominant cohort. It reportedly shaped the way the dominant cohort viewed their role in engineering, and hence the confidence which this legacy brought to their field of study. One participant described this exchange as:

> *"I feel that a lot of the men studying have male role models, like their dads influencing them to be here . . . "* PN13

Another participant articulated the core of the issue in this statement captured, regarding female underrepresentation in engineering:

> *"If I were to point out the main setback currently, it would be the appeal of engineering. I don't think many girls are brought up with the idea that they could be engineers one day, and later in life it's not exactly appealing to a lot of girls to enter a field where you're going to be the odd one out".* PN12

Participants articulated their need to belong within a dominant engineering culture. They expressed a need to find a place, made more complicated given the assumed roles of the dominant (male) culture. Given that the participants are a minority cohort in the Engineering School, this acknowledgement of a dominant, occupied space was labelled by one participant as:

> *"Men have an accepted place at university (studying engineering). They belong there. Women need to find a place to fit in".* PN02

Education Cultural Environment

The social construct of the minority group in a university environment can be difficult to navigate for new students. Given the underrepresentation of women in engineering,

this presents challenges for women interacting with a majority, or the dominant group (e.g., male peers) within their study domain. Participants described the experience at university as both not being what they had imagined engineering would look like, but also containing multifaceted hardship in terms of open stereotyping and antiquated ideologies being imposed upon them. In addition, their experiences were explored in situ with regard to opportunities alongside peers. Their experiences ranged from not feeling excluded, just acknowledged a lone woman within a majority male cohort, to receiving treatment including active discrimination and gender ignorance.

Participants confirmed they understood the minority recognition in the eyes of the majority cohort. The recognition was based upon a pragmatic approach and attitude towards the minority status. A participant described the notion of being the only woman in the group and felt quite attuned to the status, given her previous status within a minority at school with males (studying physics):

> *"I know we (women) stand out in class, but I can't say I've ever felt excluded"* PN09

Engagement with the majority cohort proved to be complicated for one participant. At the outset of starting her engineering degree, there had been discriminatory and devaluing behaviour directed at her on many occasions. One interaction she experienced occurred on the first day of class where she endured taunts. She described the interaction as hurtful and a belittling experience:

> *"My first day I was approached by a group of males in the same lecture of me who told me "nursing is down the hall". (This university) does not offer nursing, so I know they weren't trying to be helpful, they were being discriminative and arrogant".* PN13

The participant described a continuing, negative experience throughout the year. This became heightened during a group activity where her feminine role and identity were imposed in a manner, she found offensive. Moreover, the male peers did not acknowledge or allow her contributions to the group. Rather, they only recognised and praised the contributions of the dominant cohort:

> *"In my first year in a group project, we had to build a (project). The males in my group would not listen to my suggestions and I got pinned with being the "secretary" every week taking notes. I noticed I would pitch a suggestion; they would shut me down then 10 minutes later one of them would repeat my suggestion and they would all exclaim how brilliant he is, and he would take all the credit".* PN13

Gendered roles and expectations were believed not only by their peers but were an internal acknowledgement and recognition of where their academic merit lay. There appeared to be an acceptance of the gendered role played out, for example in group assignments. One participant highlighted where her skills and capabilities set her apart from the majority cohort, acknowledging:

> *"I knew from the outset that I wrote better and laid out my notes better than the guys, so it was assumed that I would fulfill that role in group assessments".* PN07

The questions were posed relating to the perception of equal opportunities in engineering. One participant described that throughout her degree, group work was a continual challenge for her to achieve equal, positive outcomes:

> *" . . . not because of the university, (but) because of the small population of sexist and arrogant men that study engineering. It is by no means everyone. I have a lot of male friends who I love in my course, but there are a small proportion who make it their goal to belittle women"* PN13

The gender normative imaginings of a stereotypical engineer are traditionally through a male gaze. Participants raised their concerns around a lack of role model. It is acknowledged that without women role models, it is complicated, if not impossible, to create imaginings of a how a particular domain may appear. One participant noted the absence

of women in engineering and stated that she had not met one in her social network at university, home or school:

> *"I would like to speak to other women engineers. I just don't know any".* PN12

Several of the students remarked that they received enduring support and gendered equivalent treatment from all the educators (irrespective of gender). One participant described that they felt recognised and seen as intelligent within a minority cohort. However, they did not feel identified in such a manner that they felt excluded from the majority. The participant described this recognition of identity as:

> *"I have never been treated differently by any of the teaching staff. In actuality (sic) they usually recognise that the girls are smart and if they have chosen engineering are more than capable of doing it".* PN13

Industry Environment and Opportunities

Participants described situations where people within their social community perceived engineering as a male profession, and were concerned about future work opportunity and cultural environment. This was perceived as a negative influencing factor even among those participants who were generally supported to study engineering by their family. Responses ranged from active discouragement to expressions of undefined concern:

> *"My parents thought engineering didn't pay well and that being one of few girls would be a disadvantage to me".* PN13

Other participants articulated future job prospect concerns, from a gendered perspective. The father was an engineer, and through his own lens of experience he had perceived engineering working environment did not welcome or include women:

> *"Dad said that it wasn't a stable job for a woman in industry . . . there weren't many jobs for women".* PN11

Moreover, responses indicated a sense of uncertainty about engineering industry as their future workplace and the urge for a platform of preparedness to work in an industry with an underrepresentation of women. One participant described the "controlled" environment she felt she was in at university and the potential unprepared risk this posed once working:

> *"I've had so many people advocating for me here (at the university) . . . However, I am a bit nervous to work in industry. I do have concerns with attitudes from other men . . . so I definitely worry how I will cope in industry".* PN07

Similarly, one participant suggested providing and/or having access to further education and engagement from the industry, to enhance knowledge and preparedness for the next industry steps:

> *"I wish there were more people from engineering to talk to us. I don't really know much about engineering in the workplace".* PN02

5. Discussion

The purpose of this article is to understand the experience of women engineering students within the Australian context. Thematic analysis of collated data suggests a set of interrelated themes, consists of underlying factors, that shape and influence the experiences of women undergraduate students. In the core of this themes are women student's self-view and the way they image themselves within the engineering context. A notable result of our study is that women students view themselves to be intellectually fit and competent for engineering, a trait that is often attributed to boys and men as being 'analytical and logical' [15,38]. This highlights that these women undergraduate students no longer see this trait as gendered characteristics. The women students also indicated the importance of support they received from their close relationships, e.g., family, friends, education community and pointed out how interacting with network of affinity

groups positively influenced their experiences and persuasion of engineering. This is consistent with Campbell-Montalvo et al. [14] and Smith et al. [66] findings emphasising the importance of network and social capital on women students' 'feelings of fit'. However, women students still view the image of engineering incongruence with their social identity, signalling the societal gender stereotypes associated with femininity and masculinity. Such a gendered construct that follows the logic of fitting in and appropriateness has led to personal challenges, such as microaggressions, imposter syndrome and a lack of confidence which all appear to be, inevitably, part of women experience studying engineering.

Our findings indicate that gendered perceptions within the broader socio-cultural context appear to be the origin of gender stereotypes surrounding engineering identity. Drawing on the dynamic relations embedded in social structure and construct of gender, our findings reveal that the broader cultural context re-produce divergent perceptions, norms and values around normative femininity and masculinity, and encourage gender congruity. While the existing construct of engineering, including its identity, education and industry environments, conform to the dominant culture and reinforce the recurring stereotypical envisioning of engineering as normative masculine profession. Such envisioning is incongruent with normative perceptions and expectations of feminine values, roles and identity, which in turn impact how women students and their networks of relationships view the appropriateness of engineering with their self-image (Figure 2).

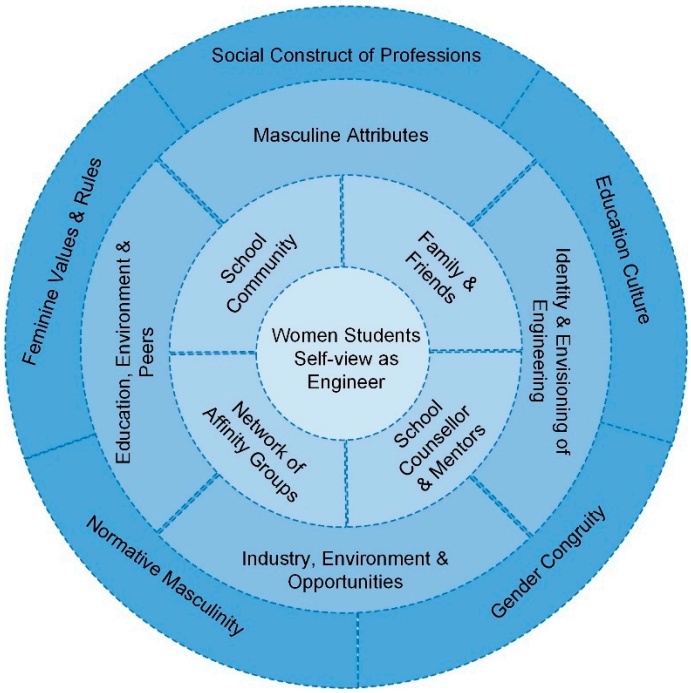

Figure 2. Dynamic relations embedded in the social construct of gender and profession impacting the experience of women engineering students.

Drawing on feminist perspectives on gender equality and inclusion in institutions [29,67] this research demonstrates that the existing gendered perceptions around the nature and image of engineering not only negatively impact women students' experiences within the bound of university but also create systemic barriers in the future workplace environment and opportunities. Despite the continuous attempt for attracting and retaining girls and women in engineering, women undergraduate students still feel that they do "not belong". They have few women peers, academic mentors and industry modelers compared to their male peers, thereby creating a wider gap for women.

Defining what it means to be an engineer and how this is identified at university and within industry are both contained within a well-defined male construct. A consistent theme of discussion within the bounds of identity was the unknown role women were to

play both at university and industry. This is in consistent with the findings of previous studies [22,52,54,68,69] pointing out that issues arise when the definition of an engineer does not include how women identify themselves. The use of feminists' lens reveals the dynamic relations between cultural perceptions and social actions. The accepted practices within social structure are embedded and indeed tied to the construction of 'appropriate' gendered roles and identities. Therefore, engineering education and industry, reproduce and reinforce such a gendered identity through a common tendency to encapsulate what constitutes a 'real' engineer, tied to the norms of masculinity, specific traits, technical skills and subsequent values.

It is apparent that women are faced with unique problems within the distinct phases of their engineering education journey. While gender inequality in STEM higher education is evident, the underlying gender norms, assumptions and values have yet to significantly change. The findings of our article indicate that promotion of what engineering could look like outside the dominant male gaze and construct is needed. This is crucial since girls and women need to be able to visualize themselves as engineers [3] to consider this as their future career choice. However, it would not be possible without a shift in the existing social construct and cultural definition of the gendered (mis)perceptions of masculinity and femininity as well as engineering identity. Such a shift towards 'co-construct' and 'co-enact' [67] will create windows of opportunities to move towards gender equity in engineering.

6. Implications and Recommendations

This study contributes to the existing literature on gender inequality in higher education, particularly building up an improved understanding of the experiences of women engineering students within the context of Australian universities. Additionally, the value of multi-disciplinary collaboration for exploring such a complex problem is noteworthy.

According to the findings of this study, we develop two implications for practice. We strongly believe that the onus for making change and improvement should be placed on socio-cultural structure and institutional systems, e.g., universities to design and implement programs to transform and address the existing barriers. First, given the positive impact of network of relationships on students' persistence in engineering [14,23,66], we suggest universities to design pathways and offer supporting programs early on during schooling (pre-university) to build a framework of engineering knowledge. The aim is to ensure students and their network of relationships, including, parents and teachers, are aware of the opportunity and possibility to study engineering for all genders and to foster the engineering interest. Some of these programs and activities include designing promotional campaign for students and parents, e.g., during holiday, school programs, teacher training and mentoring school students.

Second, considering the importance of role model and fitting in within the engineering domain [3,24], we recommend universities build upon the supportive framework underpinning change initiatives. The aim is to promoting an inclusive, and less male-oriented, image of engineering. This enables women and underrepresented minorities imaging themselves as engineers. Some of these programs can be mentoring of staff to ensure equitable treatment of women students, promoting and advocating inclusion policies, e.g., diverse representation, mentoring engineering students through women in engineering interest groups, industry engagement programs, e.g., alumni engagement, mentorships by women engineers and social networking. Implementing these programs, along with other meta programs, e.g., in media, not only creates an inclusive environment but also reaffirms the student's engineering qualifications and industry readiness. Excelling in these programs may break down some of the existing barriers to entry and increase persistence in the engineering discipline.

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