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Proceedings of the International Conference on Advanced Research in Education, Teaching, and Learning, Vol. 2, Issue. 1, 2025, pp. 1-13
DOI: https://doi.org/10.33422/aretl.v2i1.846

ISSN: 3030-0606 online

A Proposed Gender Equality Framework for Female Engineering Students in South Africa: Phase One

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Abstract

Worldwide, women are under-represented in traditionally male-dominated fields such as engineering and in academia. In Europe, initiatives such as Athena Swan have been implemented so that universities can formally commit to gender equality. The Systemic Action for Gender Equity (SAGE) is another European Charter which implements interventions to advance gender equality in seven European universities, supporting structural, cultural and political change to eradicate sexism, bias and discrimination. Progressive gender equality policies and equity clauses have been enacted in some African countries including South Africa and Kenya. However, gender skewing is still prevalent in universities in terms of throughput, completion rates, study areas and postgraduate enrolment. This research proposes the development of a gender equality framework for a South African university by reviewing literature on gender mainstreaming, gender equality frameworks and gender analysis including the South African gender context and women in academia, particularly, the attraction and retention of women in engineering fields. Based on the literature study, a gender equality framework process comprising of four phases was proposed to obtain baseline information regarding the current state of gender equality strategies within engineering fields using gender analysis as well as manufacturing and university sector status quos. A gender quality framework is then proposed to support the inclusion and retention of gender diverse communities. The proposed gender equality framework for universities could contribute to retaining women in male-dominated fields as well as highlighting discrimination and inequality practices in policies and processes, culture and the classroom. This equality framework is vital to attract, retain and support women in traditionally-male dominated fields such as engineering.

Keywords: women engineering students, gender equality, retention

1 Introduction

The SustainabilityX® Magazine (SustainabilityX®, 2023) refers to the World Bank, who stated that social inclusion is the right thing to do, in addition to it making good economic

sense. They further state that the exclusion of certain groups can be costly as its impacts include the loss of wages, lifetime earnings, poor education and employment outcomes. It further indicates that promoting social inclusion also means "embracing diversity - and that includes the aspect of gender" (SustainabilityX®, 2023). According to the Global Gender Gap Report 2021 (World Economic Forum, 2019), another generation of women will have to wait for gender parity as the coronavirus pandemic (COVID-19) impact continues to be felt, increasing the global gender gap by a generation from 99.5 years to 135.6 years.

The issue of gender inequality is a pervasive one that has become a critical topic of discussion and debate in throughout the world. The discourse on gender equality has revealed that symbolic objectives can only be achieved by implementing gender-specific interventions that consider the holistic challenges facing proponents of true equal participation (Albertyn, 2011; Bacchi et al., 2005; Barbosa et al., 2014; Bleijenbergh & Voorspoels, 2019).

All levels of discourse have indicated the significance of moving from procedural concepts and symbolic frameworks to purposeful strategies and measurable outcomes, ranging from Charles Gore highlighting the ineffectiveness of international declarations (Bleijenbergh & Voorspoels, 2019; Unterhalter, 2012; Wildschut, 2008) to detailing the challenges associated with gender equality in academia.

Transformation has been slow regardless of the rise of the feminist movement, the adoption of international declarations and conventions, and the inclusion of gender issues within national and institutional policies. The primary aim of systematic analyses is to bring an understanding as objectively as possible of what the gender dynamics are within a certain situation as the basis for drawing conclusions on whether it responds to different gender interests and expectations (Kabira & Masinjila, 1997). In planning this study, the researchers will be following the Deming Cycle, as proposed by Systemic Action for Gender Equity (SAGE) in their development, of plan, do, check and act. Accordingly, this paper reports on the "plan" phase of this cycle (SAGE, n.d.).

2 Dimensions of Gender Mainstreaming

In an effort to address the underrepresentation of women in engineering fields and cultivate a more inclusive and diverse academic environment, this study seeks to design and implement an initial phase of a gender equality framework tailored specifically to attract and support female engineering students. Therefore, simply put, the aim of this research is to propose the development phases of a gender equality framework for a South African university. The process starts with reviewing literature on gender mainstreaming, gender equality frameworks and gender analysis. The South African gender context and women in academia are discussed and of particular interest to the researchers is the attraction and retention of women in engineering fields. Based on the prior literature research, a gender equality framework process comprising of four phases was proposed. Therefore, this research provides a process to obtain baseline information regarding the current state of gender equality strategies within the field of engineering at the university by means of a gender analysis (Phase One), the status quo in the manufacturing sector (Phase Two), the university (Phase Three) and then propose a gender quality framework to support the inclusion and retention of a gender diverse student and facilitator community (Phase Four).

A number of successful gender frameworks were reviewed prior to proposing Phase One of this research study, taking key aspects from each. Based on the review of the processes of SAGE (n.d.), the European Institute for Gender Equality (EIGE) (European Institute for Gender Equality, n.d.), as well as Swedish International Development Cooperation (SIDA)

(Swedish International Development Cooperation Agency , n.d.), a gender analysis was highlighted as a key starting point for gender mainstreaming and, ultimately, the creation of a toolkit. Gender analysis refers to the process to obtain the necessary data and information to integrate a gender perspective into policies, programmes and projects. As a point of departure for gender main streaming, gender analysis aims to identify the differences between women and men in terms of "their relative position in society and the distribution of resources, opportunities, constraints and power" (EIGE, n.d.) in a given context. For EIGE (n.d.), conducting a gender analysis allows for the development of interventions to address gender inequalities and, therefore, meet the different needs of men and women. Gender mainstreaming refers to integrating gender perspectives into the content of polices and addressing representation of women and men in a given area (EIGE, nd).

EIGE (n.d.) highlights the key differences between a gender audit and a gender analysis. A gender analysis is defined as a critical examination of how differences in gender roles and activities, needs, opportunities and rights/entitlements affect men, women, boys and girls in certain situations or contexts (March et al., 1999). Further to that, it is the study of the differences in the conditions, needs, participation rates, access to resources and development, control of assets and decision making. EIGE (n.d.) suggests three steps that should be taken when conducting a gender analysis and these will be implemented in the study, including:

1. **Collect available data:** For the purpose of this study, it is proposed that questionnaires will be distributed to engineering students at one South African university.
2. **Identify gender differences and the underlying causes of gender inequalities:** In a South African context where male and female roles are very traditionally defined (Khosa-Nkatini et al., 2023), the results from a gender analysis may differ extensively to that of other third world countries and may have an influence on the next step in the process identified by EIGE.
3. **Informing policies, programmes and projects:** The results from the data collected will be presented to relevant committees and project leaders and further facilitation may be required.

SIDA (n.d.) further highlights the importance of conducting a gender analysis prior to any intervention and further explain that a gender analysis allows for the development of responses that are better suited to remedy gender-based inequalities and to meet the needs of different population groups. This is a key step in Phase One of the research and the ultimate aim of the entire process, which is to remedy gender-based inequalities. A gender analysis not only serves as a baseline for intervention, (SIDA, n.d.), but also as a starting point for the choice of strategy to apply as it is important to note that cultural and societal differences can influence the rollout process. The second step of the process in their gender toolbox is to identify how the results are to be reached. (SIDA, n.d.) Following this is the integration of gender equality, which is a goal of the programme or intervention and must be visible throughout the intervention. These components must be clear and must produce results. This integration also includes all gender categories and their roles and relationships. SIDA (n.d.) explains that by targeting specific issues and concerns, can contribute to the long-term goal of gender analysis. These steps will be adopted in Phase Two of the research through various initiatives, training and workshops.

The study of SAGE's toolkit showed a slight difference in the mode of commencement as their focus is the pursuit of gender equality in research. For this reason, SAGE collected data within the institution and conducted a gender audit. A gender audit, is defined (SAGE, n.d.), as a type of "social audit" that examines an organisation's activity from a gender perspective. From their research, SAGE (n.d.) created a self-assessment template that can be used as a tool to assess the relevant institution and their implementation process is structured in three phases, namely:

1. **Institutional self-assessment.** This requires the collection of both qualitative and quantitative data. For the research at the South African university, this will be conducted through surveys and focus groups with engineering students, allowing us to capture both statistical trends (e.g., enrolment numbers, retention rates) and personal experiences (e.g., perceptions of classroom climate, mentorship opportunities).
2. **Construction and implementation of gender equality plans**. Based on the self-assessment, SAGE partners will create a unique plan which will be guided by the SAGE Wheel Model. In the context of the South African university, this plan will be informed by insights from Phase One's data (e.g., identified biases, gaps in policy) and will include targeted interventions, such as establishing mentorship networks, revising recruitment strategies for female staff, and crafting inclusive curricula for engineering courses. This forms part of the study's Phase Three.
3. **Embedding gender knowledge in organisations.** SAGE will create a number of resources, training and workshops for the institution, which is also included in Phase Three of the study. At the South African university, these resources will be tailored to address local socio-cultural factors influencing gender dynamics, ensuring that faculty, administrative staff, and student leaders receive practical tools to sustain gender equity initiatives well beyond the project's duration.

As a starting point in the planning process, the South African gender equality context is discussed in Section Three.

3 South African Gender Equality Context

The South African context is an interesting and complex case study in gender equality owing to the restructuring of policies regarding access to resources, services and opportunities following the advent of democracy in 1994 (Masenya, 2023). The intersectional nature of gender inequality in South Africa (Mdlenleni et al., 2021) has caused race, class and gender to Influence women's access to rights, services and goods as well as the redistributive policies implemented have largely neglected the struggles of women in South Africa, upholding the hierarchies of gendered recognition (Albertyn, 2011). However, some progress has been made in the recognition of women within the legal and policy frameworks of South Africa. This includes the gender equality policy framework in South Africa, the Constitution, the National Gender Policy Framework, and the Commission for Gender Equality (CGE) which have been established to promote and develop gender equality. This regulatory and institutional architecture sets a promising precedent; however, it is crucial to examine how these principles of gender equality are echoed within specific contexts, such as academia, which is the focus of Section Four.

4 Gender Equality within Academia

Women, internationally, have fewer opportunities for access to and participation within the economic, political and education sectors and face greater health and safety risks than men (Peace Corps, 2021). The Global Gender Gap Report (World Economic Forum, 2019) finds that even when women's skills are aligned with competitive fields, they still encounter barriers to employment especially within STEMM (science, technology, engineering, mathematics, and medicine) occupations. Furthermore, even when gaining access, the report found that women are underutilised within their fields (World Economic Forum, 2019) and that gender representation varies between disciplines and between undergraduate, postgraduate and seniority within higher education institutions (Abelson et al., 2016; Bleijenbergh & Voorspoels, 2019).

The underrepresentation of women in senior academic positions is an international concern. Although more women graduate from institutions of higher learning than men, an unequal gender structure still exists within academia, with men occupying markedly higher positions than women in universities (Haake et al., 2013). The academic glass ceiling is a phenomenon experienced internationally in higher education. Studies have consistently found that despite the fact than in many cases women outnumber men in academic programmes, women are underrepresented in academic leadership positions (Abelson et al., 2016).

Gender discrimination is an issue dealt with by female academics globally, to a larger degree than their male counterparts (Abelson et al., 2016). The persistence of gender stereotypes associated with female academics, such as the perception that they are polite, sympathetic, and nurturing influences the choice of academic field by nudging women away from STEMM fields (Park, 2020). However, this also constrains women from early promotion and counteract these perceptions, women are subjected to increased emotional labour in an effort to inspire career progression at the same rate as men in academia (Burkinshaw & White, 2017; Chen & Hsieh, 2018).

Researchers have suggested various reasons for the existence of the gender gap and lack of female representation in academia. Firstly, researchers suggest that the lack of visible female mentors and role models not only decreases productivity of women within academic fields, but also impedes the professional socialisation process (Abelson et al., 2016; Burkinshaw & White, 2017; Zulfiqar et al., 2020). The lack of female mentorship in STEMM fields produces narrower pathways for women owing to the smaller networks to the research community, where there exists what Park (Africa Check, 2014) calls an "old boy's club" providing access and support to men in STEMM fields (Van Rooyen, 2021).

A second reason cited for the persistent gender gap in academia is the lack of job security often faced by women receiving short-term contracts. Generally, women occupy the majority of part-time, casual and short-term contract positions (Gilbert, 2020; Park, 2020). The precarious nature of their positions, therefore, result in women adopting heavier workloads and increased emotional labour in their wish to secure their place within academia (Burkinshaw & White, 2017). A third reason cited to perpetuate the gender gap in academia is the concern for lifestyle or quality of life concerns for women in academia (Abelson et al., 2016; Zulfiqar et al., 2020).

Women, in particular mothers, are forced to negotiate both family commitments and academic institutions without sufficient time, support, and resources (Burkinshaw & White, 2017). The attrition of women within academia can be partially explained by women dropping out in their mid-thirties, citing family commitments (Gilbert, 2020). Again, citing the characteristics of managerial modern academic careers are contingent upon flexibility,

mobility, and the assumption that those appointed are available to work long hours (Burkinshaw & White, 2017). This then excludes women, who owing to the societal gender stereotypes, are still responsible for most unpaid labour in family settings (Wildschut, 2008).

In instances in which positive discrimination in the form of gender quotas were implemented, it was found that it undermined the process of mainstreaming as the assumption is that once this measure is applied, gender mainstreaming has been achieved- despite the lack of lasting change in institutional operations (Bacchi et al., 2005; Van Rooyen, 2021). While the use of gender quotas has been explored as a solution, it is clear from the literature that systemic change involves more than just numerical representation. With this in mind, Section Five discusses the male-dominated STEMM field, namely, engineering to investigate the specific challenges and opportunities for women in this sector.

5 Women in Engineering

Nationally and internationally, the fields of science and engineering face major challenges in producing the necessary workforce for the future. The first major challenge is recruiting students, especially women, to these fields and the second challenge is retaining those who do enrol until they complete their qualifications (Hutchison et al., 2006). Studies by Network Engineering (Thompson, 2015) Have Identified A Third Challenge, Namely, The Retention Of Working Women Engineers. They Found That 70% Of South African Women Engineering Graduates Left The Sector After They Started Their Careers (Thompson, 2015). Reasons Cited For This Were That They Felt Isolated In Their Jobs, As Professional South African Women Engineers Continue To Battle With Old Stigmas In This Male-Dominated Industry.

Innovation And Technology Play An Increasingly Critical Role In Today's Knowledge-Based Economy And, therefore, gender equity in STEM (science, technology, engineering, and mathematics) focused research and education is extremely important (European Commission, 2021). To this end, Brigitte Ratzer (European Commission, 2021) a researcher at TU Wien's office for gender competence states that:

> "From how we move to the way we communicate, work and recreate – science and engineering play an essential role in our tech-filled lives. By ensuring the consideration of sex and gender in the science and engineering behind much of today's technology, we also ensure that this technology is equally available and useful to everyone".

Information Systems Audit and Control Association's (ISACA's) 2017 Women in Technology Study (ISACA, 2017) found that many challenges still need to be addressed to solve the problem of a persistent gender bias in the workplace as well as continued pay gaps and a lack of female mentors. The ISACA study proposed that the five of the most common obstacles that women encounter are a lack of mentors and female role models in the field, gender bias in the workplace, unequal growth opportunities compared to men and unequal pay for the same skills. González-González et al., (2018) suggested that communities generate initiatives, actions and programmes and promote the common shared goals of sensitisation of the environment and society, making women who work in the field of technology more visible and creating role models so that women have female references. González-González et al., (2018) further suggest the development of female engineers by advocating women in leadership roles and engaging and encouraging girls to embrace technology fields at a young age. In addition, learning in basic technology and STEM skills must be promoted and equality between women and men with a focus on access to research

activities in STEM and equal opportunities throughout the career for women researchers and technologists (González-González et al., 2018). Charlesworth and Banaji (2019) proposed that to understand the possible role of implicit and explicit biases in the STEM field, the extent of the biases needs to be examined.

Charlesworth and Banaji (2019) further ask the question if implicit and explicit biases do play a causal role in gender disparity in STEM, how would one know and what would the evidence for bias look like. Gender-based initiatives in all target areas in Africa is needed to contribute to a new socio-cultural and gender identity for women in Africa (Fomunyam et al., 2020). They further propose that closing the gender gap in engineering education is of critical importance in Africa because failure to do so will result in the loss of vast human resources that can contribute to national development and reinforce gender equality in society and particularly in traditionally male-dominated fields such as engineering (Fomunyam et al., 2020).

6 Methodology

This study uses a qualitative approach, utilising document analysis, within a case study research design to develop an understanding of gender equality issues within a South African university to enable the planning process for the overall research study. By adopting a case study design, the study captures context-specific insights, which are critical for formulating a targeted gender equality framework.

6.1 Data collection

Data collection for this study primarily consisted of a comprehensive document analysis (Bowen, 2009). This entailed a meticulous review of relevant institutional policies, academic articles, reports, meeting minutes and other public documents related to gender equality practices within the university and its School of Engineering. In addition to institutional documents, national and international policies on gender equality in academia were also examined to provide broader context and benchmarks.

To enhance the depth and credibility of the document analysis, a purposive sampling strategy was employed: we selected documents based on their direct relevance to gender policies, institutional strategic plans, and operational guidelines within the School of Engineering. This also included departmental memos and records of diversity-related initiatives spanning the last five years. By ensuring that documents were drawn from multiple levels (institutional, national, and international), the study incorporated a comparative dimension, enabling cross-validation of findings. Moreover, any ambiguities identified in these texts were clarified through informal discussions with key administrative and managerial staff, thereby increasing the reliability of the collected information.

6.2 Data Analysis

The data procured from the document analysis was subjected to a rigorous content analysis process (Krippendorff, 2013) which facilitated a detailed understanding of the process involved in designing a gender equality framework. To ensure analytical rigour, each document was coded using a three-step process: (i) preliminary open coding to identify recurring themes or references to gender-related issues; (ii) axial coding to link these themes across different types of documents (e.g., institutional policies vs. national guidelines); and (iii) selective coding to form overarching categories relevant to the proposed gender equality framework. Throughout this iterative process, two independent coders reviewed the

documents to check for consistency and minimise subjective bias. Discrepancies between coders were resolved through discussion until consensus was reached, thereby strengthening the trustworthiness of the analysis. Additionally, key themes emerging from the coded data were compared against existing literature on gender equality frameworks to validate their relevance and alignment with recognised best practices. The outline of developing a gender equality framework is discussed in Section Seven.

7 Proposed process

Drawing on the discussion in Section Three, which identifies South Africa as a complex setting for gender equality due to the intersectional influences of race, class, and gender (Albertyn, 2011), this process incorporates both national legal frameworks and broader socio-cultural dimensions pertinent to South African higher education. Further informed by the preceding literature review and established institutional procedures, the subsequent steps outline the planning phase for developing a gender equality framework at a South African university.

7.1 Phase One

Phase One was initiated by conducting a literature study and researching a gender equality framework and the processes involved in its development. Special focus was placed on the South African context and the current situation within the engineering field.

The next step in this phase was to develop a gender analysis questionnaire for engineering students at the University, aimed at understanding how gender influences their experiences of becoming and being engineering students. Results from this questionnaire and supplementary interviews will provide insight into the current situation within the School of Engineering, informing suggestions for training, initiatives, and workshops as well as shaping relevant policies, programmes, and projects. These findings will also guide the subsequent phase of the study, focusing on the local manufacturing industry.

Furthermore, to strengthen the framework's originality and contextual relevance, particularly given South Africa's evolving policy environment and intersectional gender dynamics, focused group discussions and one-on-one interviews will capture the unique socio-economic and cultural factors affecting women's experiences in engineering. These insights will guide the development of context-sensitive strategies, such as targeted mentorship programmes, flexible course scheduling that accommodates diverse student backgrounds, and culture-specific inclusion workshops that address local gender norms.

7.2 Phase Two

This phase will commence with a more detailed literature study and research into the current situation of women in the fields of engineering in South Africa. An overview of the Eastern Cape Manufacturing Industry (ECMI) will be provided in addition to female representation and the leaving rate of women in the field. A gender analysis tool will be developed based on a literature study and the findings of Phase One. The aim of conducting the tool is to establish gender equality perceptions and insight into the culture of the ECMI. The disaggregated data should also provide insight into perceptions of discrimination and inequality and how "friendly" the industry is towards women. Additionally, data regarding policies, non-discrimination, composition and integration, advancement, recruitment, monitoring, deconstructing excellence, gender awareness and bias, leadership accountability, funding,

research, knowledge, visibility, care and family life, work-life balance (Schmidt & Graversen, 2020) will be gathered.
Building on the Phase One findings, we anticipate that these results will lead to new initiatives, training, and workshops in collaboration with local manufacturers and industry leaders, ultimately supporting the development of a gender mainstreaming strategy for the manufacturing sector. In recognising the systemic barriers rooted in both historical and contemporary inequalities, we plan to convene regional "Women in Engineering Roundtables" to address issues identified by the student survey, launch pilot mentorship networks connecting female students with experienced ECMI engineers, and design professional development modules and short learning programmes tailored to the challenges specific to the South African manufacturing sector.

7.3 Phase Three

Based on the findings of Phases One and Two, as well as a thorough literature review, a gender audit will be conducted at the University to examine policies, procedures, and processes through both quantitative and qualitative methods. The goal is to identify strengths and weaknesses in terms of gender equality issues related to culture, policies, and practices.

By integrating the audit outcomes with insights from the earlier phases, we aim to capture the current situation and design targeted training and initiatives, culminating in a gender equality framework that supports gender mainstreaming and fosters a comprehensive gender equality strategy. To ensure specificity and practical impact, the audit process will incorporate tailored benchmarks, such as measurable improvements in the recruitment, retention, and promotion of women in engineering faculties, and involve close collaboration with institutional leaders to set clear targets (e.g., increased female enrolment, expanded scholarship support, and targeted bias training for staff). By explicitly addressing the intersectional challenges facing South African women, these audit outcomes will shape policies and practices that support genuine, transformative change.

7.4 Phase Four

This phase will involve national collaboration with other universities to finalise gender equality framework for South African universities. During this phase, best practices gleaned from the pilot initiatives and audits in Phases One to Three will be consolidated into a national roadmap. In particular, participating institutions will share data-driven insights, such as effective mentorship structures, policy amendments, and industry-academic partnerships, so that the framework reflects both regional diversity and overarching principles of gender equality enshrined in South African policy frameworks. This collaborative approach ensures that the final framework offers clear, implementable steps adaptable to different university environments while maintaining the nuance required to address the complex intersectional dynamics of the South African context.

8 Conclusion

Through the examination of existing literature and ongoing initiatives, this study underscores the importance of distinct phases in the creation of a gender equality framework, emphasising the need for a strategic approach to maximise impact and pave the way for change. Review of the successful gender frameworks indicate that a gender analysis is the first and most important step as this provides a context of the status quo in which the framework needs to operate. In Phase One, this will focus on engineering students, while Phase Two focuses on the current situation in industry. This information will provide the researcher with an overall

view of the transition from higher education to a corporate or industry environment and the framework that is proposed can highlight this and provide the necessary tools for this transition as well.

The retention of women in engineering fields is a global issue as the traditional male and female roles and biases are still prominent in both academic contexts as well as in work environments. There is still a global push to remedy inequalities, address the skills gap and remove barriers linked to career progression for women. Therefore, the need for a framework to be used both in higher education facilities as well as corporate facilities is important.

Research has indicated that there is still a major underrepresentation of women in leadership roles, particularly in higher education institutions and by conducting Phase One of the project, with the engineering students at a South African university, the outcomes will provide a clear understanding of the current situation. In addition, the data collected will be key to designing and facilitating workshops, and will inform the way forward.

To enhance the practical implications and clarity of the project's results, we will integrate localised economic and cultural insights, such as institutional capacity, policy alignment with national gender directives, and existing mentorship initiatives, into the subsequent phases of this study. The findings from the initial gender analysis (Phase One) will directly shape the tailored interventions proposed later, as survey data and interview insights are expected to reveal specific institutional barriers (e.g., limited mentorship opportunities or implicit classroom biases). These barriers can then be addressed through context-specific training modules and strategic policy reforms. By drawing on concrete case examples from both higher education and corporate settings, we aim to develop action-oriented recommendations, such as policy revisions, targeted recruitment, and retention strategies, that reflect South Africa's socio-economic realities and broaden the framework's applicability. This direct linkage between empirical evidence and targeted measures ensures that the framework remains responsive to the real-world challenges faced by female engineering students, ultimately maximising both its impact and adaptability.

In other words, with diligent execution and careful analysis, the information gleaned from this research will serve as a cornerstone for designing a robust and effective gender equality framework, contributing to the much-needed transformation in the representation of women within the engineering sector. While the framework presents a strategic and comprehensive approach to addressing gender disparities, its successful implementation may encounter certain challenges and necessitate specific contextual considerations. It is, therefore, important to recognise that the proposed gender equality framework, while guided by extensive literature and insights from participants, may not be universally applicable in all engineering contexts. Several potential limitations warrant consideration:

- **Contextual Variability:** The dynamics of gender disparities and the challenges faced by women engineers can vary significantly across institutions, engineering disciplines, and geographic locations. As such, the framework's effectiveness may be influenced by the unique characteristics of each context.
- **Resource Availability:** The successful implementation of certain strategies within the framework, such as mentoring programmes or tailored professional development initiatives, may require substantial resources in terms of time, funding, and personnel. Limited resources could impact the extent to which these strategies can be executed.
- **Resistance to Change:** Introducing changes to organisational culture and practices, as proposed in the framework, may encounter resistance from stakeholders who are

not aligned with the goals of gender equality. Navigating and overcoming this resistance could present challenges.

While acknowledging these potential limitations, it is crucial to identify the conditions under which the proposed framework is likely to be most effective. Consideration of these conditions can guide the strategic implementation and maximise the impact of the framework:

- **Leadership Commitment:** The active endorsement and commitment of organisational leadership to fostering gender equality is fundamental. A supportive leadership stance can facilitate the integration of the framework's strategies into the institution's policies and practices.
- **Collaborative Engagement:** Successful implementation requires engagement and collaboration across various stakeholders, including administrators, faculty, staff, and students. A collective effort can ensure a holistic and sustained approach.
- **Tailoring to Context:** Adapting the framework to the specific characteristics and challenges of the institution and engineering discipline is vital. Tailoring strategies to the local context enhances the framework's relevance and resonance.
- **Continuous Assessment and Adaptation:** Regular evaluation and iterative refinement of the framework based on feedback, data, and evolving needs are crucial for its long-term effectiveness.

By linking the anticipated findings from Phases One and Two to the above conditions, we illuminate both the theoretical foundations of the framework and the practical steps needed to address identified barriers. This integrated approach underscores the framework's capacity to drive meaningful change, continuously adapting to emerging challenges and stakeholder feedback. Moreover, by acknowledging the framework's limitations and delineating conditions for successful implementation, we present a balanced view of its potential. As our research progresses, we will validate and refine these elements through empirical data, thereby enhancing the framework's applicability and impact on gender equality in higher education.

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