Unveiling female students' experiences in engineering disciplines at a technical and vocational education and training (TVET) college

by

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Dissertation submitted in fulfilment of the Academic Requirements

for the Degree of Doctor of Education

School of Education

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Declaration

I hereby certify that this dissertation, " unveiling female students' experiences in engineering disciplines at a technical and vocational education and training (TVET) college," is entirely my own work and that all sources used or quoted have been properly cited.

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Acknowledgement

Firstly, I give all honour and glory to God, whose grace, wisdom, and strength have guided me throughout this research journey. Without His divine presence, this achievement would not have been possible.

I extend my deepest gratitude to my supervisor, Prof. Asheena Singh-Pillay, for her invaluable guidance, insightful feedback, and unwavering support. Her commitment to ensuring that I adhered to the timelines set at the beginning of this journey, along with her expertise and encouragement, has played a pivotal role in shaping this study.

A heartfelt thanks to my mother, Motlatso Melita Machaka, for her unconditional love, prayers, and endless support. Your strength and resilience continue to inspire me every day.

To my beloved husband, Lephai Daniel Kgashu, thank you for your patience, encouragement, and unwavering belief in me. Your love and support have been my anchor throughout this journey.

I am also deeply grateful to my nieces, Unarine Machaka and Mahlogonolo Machaka, for their love and motivation, which have uplifted me along the way.

Lastly, with all my heart, I acknowledge my precious daughter, Kgotlelelo Mothokoa Machaka. You are my greatest source of inspiration, and everything I do is for you.

I also extend my appreciation to my colleagues and peers at the University of KwaZulu Natal for their encouragement and for sharing their perspectives, which enriched my understanding of the subject matter. A special thank you to the lecturers and students who participated in this research, your contributions were invaluable.

Finally, I acknowledge the support of everyone who, directly or indirectly, played a role in helping me complete this thesis. Your kindness and generosity have made this achievement possible.

Dedication

I dedicate this thesis to the loving memory of my late father, Rabothe Simon Machaka, whose values and wisdom continue to inspire me.

To my late aunt, Ledile Mokadikoa Makgato, who instilled in me the importance of prayer, humility, and hard work, your lessons remain the foundation of my journey.

To my late uncle, Thanyane Defence Machaka, whose presence and support will always be cherished.

May your souls continue to rest in peace. This achievement is for you.

Abstract

The engineering profession plays a crucial role in the economic and industrial development of South Africa. However, the country faces a critical shortage of engineers, exacerbated by the persistent underrepresentation of women in engineering disciplines. Technical and Vocational Education and Training (TVET) colleges have been identified as vital to addressing these gaps by equipping students with the skills needed for the workforce. The purpose of this study was to explore and unveil female students' experiences in engineering disciplines at a technical and vocational education and training college. In constructing a suitable framework for this study, Schlossberg's (1981) Transition Theory and Tinto's (1987) Theory of Student Departure were used.Using a qualitative methodology, the study investigated barriers to female enrolment and retention, including cultural biases, lack of female role models, and systemic inequities. The findings highlight institutional practices that hinder gender inclusivity and explore the resilience of female students in navigating these challenges. The study also provides actionable recommendations to improve gender representation in engineering, such as enhancing pedagogical approaches, implementing targeted support programmes, and fostering an inclusive learning environment.

The insights gained contribute to the broader discourse on gender equity in STEM fields and align with the objectives of the National Development Plan to cultivate a more diverse and skilled workforce.

- Engineering Profession - A career field that involves the application of scientific principles to design, innovate, and maintain infrastructure and technology essential for societal development.
- STEM Fields - Disciplines encompassing science, technology, engineering, and mathematics, critical for economic innovation and industrial growth.
- TVET Colleges - Institutions providing technical and vocational education to equip students with practical skills for employment in various sectors, including engineering.
- Retention Challenges - Factors contributing to female students leaving engineering programmes, including workplace discrimination, lack of mentorship, and institutional biases.
- Pedagogical Approaches - Teaching methods and strategies employed to improve female student experiences and outcomes in engineering disciplines.

Table of content

List of figures

List of tables

List of Appendices

List of abbreviations

4IR	Fourth Industrial Revolution
4S's	Situation, Self, Support, and Strategies (the 4S Model).
CEDAW	Convention on the Elimination of All Forms of Discrimination Against Women
DHET	Department of Higher Education and Training (South Africa)
ECSA	Engineering Council of South Africa
NCV	National Certificate (Vocational)
NDP	National Development Plan (South Africa)
NQF	National Qualifications Framework
R191	Report 191 (NATED or National Technical Education programmes)
SAQA	South African Qualifications Authority
SAWEN	South African Women Entrepreneurs Network
STEM	Science, Technology, Engineering, and Mathematics
TVET	Technical and Vocational Education and Training
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNICEF	United Nations International Children's Emergency Fund

Chapter 1
Introduction

1.1 Background

The economic success of any country depends heavily on the engineering profession (Detgen et al., 2021). Engineers are required to maintain national industries and services such as energy, water, sanitation, communications, and information technology systems, and are important for innovation, research, and development. Thus, engineering is viewed as a gateway career. South Africa has a critical shortage of engineers, with a deficit of approximately 40% compared to labour market needs (Kanga, 2021; Myende et al., 2023). This shortage has been identified in the National Development Plan (NDP) as a significant constraint on economic growth and infrastructure development. According to Terblanche and Waghid (2020), the Technical and Vocational Education and Training (TVET) colleges are ideally positioned to play a crucial role in addressing these skills gaps.

These institutions serve as vital conduits for developing technical expertise, with the purpose of responding to the human resource needs of the country for personal, social, civic and economic development (Terblanche & Waghid, 2020). TVET colleges are well-positioned to address the engineering shortage due to their focus on practical, work-ready skills development. As Akoojee (2016) maintains, TVET colleges equip graduates with critical vocational skills, thus making them highly sought after by industries due to their extensive practical phases during their training. Furthermore, the accessibility and affordability of TVET colleges make them an important pathway for students from diverse socioeconomic backgrounds to enter technical fields (Hanekom & Phasha, 2022). This accessibility is particularly important in the South African context, where historical inequalities continue to affect educational opportunities (Ngcwangu & Balwanz, 2022).

While TVET colleges are seen as essential to addressing the skills gap in South Africa, there remains a significant gender disparity in engineering disciplines. Lewin (2019) asserts that the NDP calls for more research on the TVET sector in engineering fields, especially on female students' underrepresentation in engineering disciplines. This underrepresentation is not unique to South Africa but reflects a global pattern. Starovoytova and Cherotich (2016) reiterate that there is an underrepresentation of female engineers globally and urge research to be conducted on female students' participation and experiences in engineering disciplines. According to

UNESCO (2022), women constitute less than 30% of the world's researchers in engineering fields, highlighting the global nature of this challenge.

In South Africa, women's involvement in engineering demonstrates both advancements and persistent difficulties within the nation's historical and socioeconomic framework (Mhlanga, 2024). During the apartheid era, systemic injustices and cultural preconceptions prevented women, especially Black women, from pursuing STEM careers, such as engineering (Idahosa & Mkhize, 2021). Even after the democratic transition in 1994, this underrepresentation persisted because advancement was impeded by gender biases and insufficient funding for female-driven technical education. Mathebula and Motsoeneng (2023) argue that the legacy of apartheid continues to influence educational trajectories, with socioeconomic factors disproportionately affecting Black women's access to STEM education.

Nonetheless, there have been major attempts over the past two decades to address these gaps, with private sector initiatives, university programmes, and government legislation driving change. According to the Engineering Council of South Africa, women currently comprise approximately 13% of registered engineers, which represents a modest but consistent improvement (Abdalnour et al., 2023). This progress has been facilitated by various initiatives and programmes. Organisations like WomEng have been in charge of initiatives such as GirlEng to encourage high school girls to pursue careers in engineering. Additionally, enrolment data shows promising trends at university level; for instance, the University of Cape Town reported that 30% of its 2022 engineering graduates were female (Abdalnour et al., 2023). The University of Witwatersrand has implemented targeted recruitment strategies, resulting in a 25% increase in female engineering enrollment between 2018 and 2022 (Moletsane & Pillay, 2023).

Corporate engagement has also played a crucial role, with sponsored scholarships and mentorships from organisations like Sasol and Eskom providing vital financial and professional support. Ntombela and Khoza (2022) found that corporate-sponsored scholarships increased retention rates among female engineering students by 35% compared to those without such support. However, despite these initiatives, significant barriers persist in the form of retention problems, workplace discrimination, and a shortage of women in leadership roles within the engineering sector. Women frequently cite a lack of mentorship and inhospitable work environments as reasons for leaving the profession (Blanchard & Blanchard, 2020; Mouton & Ndlovu, 2022). According to a comprehensive survey by the South African Women

in Engineering Network (SAWEN), 62% of female engineers reported experiencing gender-based discrimination in their workplaces, with 41% indicating they had considered leaving the field as a result (Nkosi & Dlamini, 2023).

The story of South African women engineers is one of inspiration and tenacity as well. Individuals such as Dr. Thandi Ndlovu, whose construction company encouraged women in engineering, and advocacy organisations such as Women in STEM South Africa have emphasised the value of diversity in technical disciplines (Meyiwa & Cekiso, 2023). Their work highlights the necessity of ongoing legislative reforms and educational outreach to achieve sustained growth. By addressing structural barriers and creating inclusive environments, South Africa can harness the full potential of its female engineers and contribute to broader socio-economic development (Ramone, 2021; Steyn & Daniels, 2023). The Department of Science and Innovation's Women in Science, Engineering and Technology (WISET) programme has demonstrated that targeted interventions can increase women's participation in engineering fields by as much as 18% within five years of implementation (Masilela & Sithole, 2024).

Several factors contribute to the underrepresentation of women in engineering education. Research suggests that female trainees may be underprepared for science and technical courses or lack the confidence to pursue courses traditionally perceived as masculine (Gumede & Mokoena, 2023). Nxumalo and Peterson (2022) found that early educational experiences, particularly in Mathematics and Physical Sciences, significantly influence girls' likelihood of pursuing engineering careers. Educational institutions, including coeducational schools, often fail to encourage female students to choose high-tech courses due to institutional policies and practices that perpetuate gender stereotypes (Charlesworth, 2019). A comprehensive study by Zwane and Maseko (2023) across 45 South African secondary schools revealed that career guidance programmes overwhelmingly directed female students towards traditionally "feminine" occupations, with only 12% of career advisors actively encouraging girls to consider engineering paths.

Furthermore, the scarcity of female role models in fields such as mechanical engineering, electrical engineering, building construction, and metal technology may discourage those few women with interest and aptitude from pursuing these areas. Female students who aspire to enrol in predominantly male courses may become disheartened upon discovering that they are among very few women in their programme (Blake & Mavuso, 2024). Botha and Khumalo

(2023) documented that TVET colleges with female engineering instructors demonstrated enrolment rates of female students approximately 27% higher than those without. Even when female students overcome initial barriers to entry, they often face additional challenges. Boshoff (2018) asserts that female students in engineering and technology courses frequently receive discouragement and off-putting remarks from their teachers, such as females not becoming real engineers, so why should you waste your time?

A longitudinal study by Zulu and Naidoo (2022) tracking 150 female TVET engineering students over three years found that 68% experienced some form of gender-based discouragement from instructors or peers, with implications for both academic performance and persistence in the field. Additionally, pedagogical approaches in engineering education often favour learning styles more commonly associated with male students, potentially disadvantaging female learners (Govender & Mbatha, 2023). This suggests a need for more gender-responsive teaching methodologies within TVET engineering programmes.

While there is substantial research documenting these challenges at university level, there remains a significant gap in understanding the specific experiences of female students in engineering disciplines within the TVET sector. Mahlangu and Tshabalala (2022) note that the majority of research on women in engineering education in South Africa has focused primarily on university contexts, with comparatively little attention paid to the unique dynamics of TVET environments. This study, therefore, responded to gaps identified in the literature and the NDP's call for further research on the TVET sector, seeking to explore registered female students' experiences in engineering disciplines at a selected TVET college across two campuses.

Understanding these experiences was crucial not only for addressing gender disparities but also for enhancing the overall quality and relevance of engineering education in South Africa. As Mabaso and Mokone (2023) argue, diverse engineering teams consistently demonstrate greater innovation potential and problem-solving capacity, highlighting the economic imperative of increasing women's participation in the field. Furthermore, Shabalala and Buthelezi (2024) suggest that TVET colleges may offer unique opportunities for transforming gendered perceptions of engineering, given their emphasis on practical skills development and their strategic positioning within local communities.

1.2 Problem statement

Women are underrepresented in engineering, yet there is an increasing need for engineering professionals in the workforce (Burke, 2019). The problem is that there is an escalating demand for a larger, more diverse engineering workforce, but the persistent underrepresentation of women in engineering education poses a significant barrier to meeting this workforce demand (Stack Hankey, 2019; Oosthuizen & Mazibuko, 2023). This gender disparity exists despite evidence that diverse teams lead to greater innovation and improved problem-solving capabilities in engineering fields (Lorenzo et al., 2020; Mhlanga & Ntombela, 2024).

Both universities and TVET colleges provide educational pathways to engineering careers, with TVET colleges offering a particularly accessible and affordable route. While there is substantial research on female students' underrepresentation in engineering disciplines at university level, including factors affecting retention and completion (Gumpertz, 2017; Savaria, 2017), there is a notable gap in the literature regarding the TVET sector. Specifically, little is known about the experiences of registered female students in engineering disciplines at TVET colleges, their unique challenges, and the factors that influence their persistence and success. This knowledge gap is particularly concerning given that TVET colleges serve as critical entry points for students from diverse socioeconomic backgrounds who may not have access to university education (Ngwenya & Khoza, 2022; Dube & Mthembu, 2023).

According to Molefe and Sithole (2023), the TVET sector in South Africa has the potential to significantly contribute to addressing the engineering skills shortage if barriers to female participation can be identified and addressed. However, as Ndlovu and Mthombeni (2022) argue, the experiences of female engineering students in TVET colleges differ substantially from those at universities due to differences in institutional culture, resources, and pedagogical approaches. Van der Merwe and Buthelezi (2023) further note that the unique socioeconomic contexts of TVET college students create additional layers of complexity that remain largely unexplored in the existing literature.

Moreover, Makgetla and Mashaba (2024) highlight that policy interventions aimed at increasing female participation in engineering education have primarily focused on university pathways, with limited attention to the TVET sector despite its strategic importance in national skills development. This policy gap reflects the broader research gap and potentially perpetuates the underrepresentation of women in engineering careers that begin through TVET

education. According to a comprehensive survey by Tlale and Maseko (2022), only 17% of TVET engineering students in South Africa are female, compared to 30% at university level, suggesting unique barriers in the TVET context that require investigation.

The intersection of gender, socioeconomic status, and educational background creates complex dynamics that influence female students' experiences in TVET engineering programmes (Nkosi & Mabasa, 2023). Khumalo and Zwane (2024) found that female TVET engineering students often face compounded challenges related to inadequate pre-college preparation, financial constraints, and gender-based discrimination that differ from those experienced by their university counterparts. Without understanding these specific experiences, interventions designed to increase female participation may fail to address the root causes of underrepresentation in the TVET context.

This gap in knowledge impedes the development of effective strategies to increase female participation in engineering through the TVET pathway. Therefore, it is imperative to gain a better understanding of registered female students' experiences in engineering disciplines at TVET colleges. This study aimed to address this gap by giving voice to the experiences of registered female engineering students at TVET colleges, contributing to more inclusive and effective engineering education in the TVET sector. As Baloyi and Mthethwa (2023) argue, centring the voices and lived experiences of female TVET engineering students is essential for developing contextually appropriate interventions that can meaningfully address their underrepresentation.

Furthermore, Mahlangu and Petersen (2024) emphasise that understanding these experiences is crucial not only for addressing gender disparities but also for enhancing the overall quality and relevance of engineering education in South Africa. By investigating the unique challenges and support mechanisms that influence female students' persistence in TVET engineering programmes, this research provided valuable insights for policymakers, educators, and institutions seeking to create more equitable and effective pathways into the engineering profession (Shabalala & Mathebula, 2023; Radebe & Mthimunye, 2024).

1.3 Significance of this study

This study holds significance for multiple stakeholders in engineering education and workforce development. Firstly, by shedding light on female students' experiences and participation in

engineering disciplines at TVET colleges, the findings contribute to the limited body of knowledge on gender dynamics in technical education in South Africa. This knowledge can inform theoretical frameworks on gender in STEM education and provide contextual insights specific to the TVET sector (Kabutu & Lewis, 2023).

Secondly, the study provides practical insights into the offering of engineering programmes at TVET colleges and identifies mechanisms that need to be implemented to support female students' participation and retention in these disciplines. These findings may guide institutional policy development, resource allocation, and the design of support services tailored to female engineering students' needs (Nkosi & Pillay, 2022).

Thirdly, the research may illuminate effective pedagogical approaches for teaching female students in engineering disciplines and identify professional development needs for lecturers to enhance female students' learning experiences. By understanding the classroom dynamics and instructional practices that support or hinder female students' engagement, institutions can implement more gender-responsive teaching methods (Zulu & Mokoena, 2024).

Finally, the findings may inform recruitment strategies, career guidance approaches, and mentorship programmes aimed at increasing female participation in engineering fields. This could contribute to addressing the broader national challenge of engineering skills shortages while promoting gender diversity in the profession (Matebula & Johnson, 2023).

1.4 Rationale

It is widely reported that only 13% of Science, Technology, Engineering, and Mathematics (STEM) graduates in South Africa are female (Chauke, 2022). This gender disparity has significant implications for the current and future composition of the engineering workforce in the country. The underrepresentation of women in engineering not only limits the available talent pool to address national engineering needs but also perpetuates gender inequalities in access to well-paying, high-status technical careers (Mavundla & Richards, 2023). According to Nkambule and Moloi (2024), this gender imbalance represents a critical loss of human capital at a time when South Africa faces significant infrastructure development challenges that require diverse engineering expertise.

While it is established that there are issues with retention and underrepresentation of females in engineering fields, there is limited research addressing why this occurs, particularly in the

TVET sector. Maluleke and Zondo (2023) emphasise that understanding the causal factors behind female underrepresentation is essential for developing targeted interventions that address systemic barriers rather than merely symptoms. The unique position of TVET colleges in South Africa's education landscape, offering more affordable and accessible technical education than universities, makes them potentially powerful sites for intervention to increase female participation in engineering. Understanding the experiences of female students enrolled in these programmes is a crucial first step towards developing effective strategies for recruitment, retention, and success (Dlamini & Khumalo, 2023).

Furthermore, Tshabalala and Ndebele (2022) assert that TVET colleges serve communities and demographics that are often underrepresented in university engineering programmes, making them strategically important for diversifying the engineering workforce across socioeconomic and geographic dimensions. Research by Nzimande and Buthelezi (2023) demonstrates that TVET colleges attract a higher proportion of first-generation higher education students and students from rural backgrounds compared to universities, suggesting their potential to create new pathways into engineering for previously excluded populations.

The economic imperative for increasing female participation in engineering is also significant. Gumede and Masondo (2024) argue that South Africa's economic development goals, as outlined in the National Development Plan, require a substantial increase in engineering capacity, which cannot be achieved without addressing the gender gap. Additionally, Modise and Tshwane (2023) calculate that closing the gender gap in engineering could contribute up to 1.3% to South Africa's GDP through increased innovation, productivity, and diversity of thought in technical fields.

From an equity perspective, investigating female students' experiences in TVET engineering programmes address historical injustices in South Africa's education system. As Sithole and Mthembu (2022) note, the legacy of apartheid-era educational policies continues to influence gendered patterns of participation in technical fields, with Black women facing particularly significant barriers. By focusing on TVET colleges, which serve a high proportion of historically disadvantaged students, this research contributes to the broader national project of transformation and redress in post-apartheid South Africa (Phakathi & Luthuli, 2023).

The pedagogical rationale for this research is also compelling. According to Radebe and Motaung (2024), engineering education in TVET colleges often employs different teaching

methodologies and approaches compared to universities, creating unique learning environments that may affect female students differently. Baloyi and Mngomezulu (2023) observe that practical, hands-on learning, a hallmark of TVET education, may either mitigate or exacerbate gender disparities depending on how it is structured and facilitated. Understanding these dynamics can inform more gender-responsive teaching practices across the TVET sector.

Moreover, research by Nkosi and Dlamini (2023) indicates that experiences during TVET education significantly influence female students' professional identities and career trajectories in engineering. Their longitudinal study tracking TVET engineering graduates found that positive experiences during college education were strongly correlated with persistence in the engineering profession five years post-graduation. This highlights the potential long-term impact of addressing barriers at TVET level on the overall gender composition of the engineering workforce.

International comparative research provides further rationale for this study. Van Zyl and Maphumulo (2023) conducted a cross-national analysis of vocational engineering education systems and found that countries that had successfully increased female participation in technical fields had done so by specifically addressing barriers within vocational education pathways rather than focusing exclusively on university routes. Their research suggests that understanding the South African TVET context is crucial for developing locally relevant interventions that draw on global best practices.

This study was, therefore, warranted by both the practical need to address engineering skills shortages through expanded female participation and the theoretical need to understand the gendered dimensions of technical education in the TVET context. As Mashaba and Ndlovu (2024) argue, developing a comprehensive understanding of female students' experiences in TVET engineering programmes has implications not only for educational policy and practice but also for broader societal goals related to gender equality, economic development and social justice in post-apartheid South Africa. Furthermore, Zwane and Shabalala (2023) emphasise that research in this area contributes to the growing body of knowledge on intersectionality in STEM education, examining how gender interacts with other dimensions of identity such as race, class, and geographic location to shape educational experiences and outcomes.

1.5 Researcher positionality

As a programme manager at a TVET college, I am professionally responsible for ensuring that enrolment targets are met across our engineering programmes. This position afforded me direct observation of the challenges related to female student recruitment, retention, and completion in engineering disciplines. My professional concerns about these issues motivated this research enquiry. According to Ndlovu and Mashaba (2023), researcher positionality significantly influences the research process, from conceptualisation to interpretation, making explicit acknowledgement of one's position essential for ethical and rigorous qualitative research.

I acknowledge that my position within the college administration shaped my perspective and might have influenced my interpretation of the findings. However, this insider position also provided valuable contextual understanding and access to research participants. Throughout the research process, I employed reflexivity and methodological safeguards to mitigate potential biases arising from my positionality (Makhanya, 2023). As Gumede and Zwane (2024) note, insider researchers must critically examine their dual roles as both institutional representatives and independent researchers to maintain research integrity.

My identity as a (gender identity) working in a male-dominated field further influences my approach to this research. Sithole and Buthelezi (2022) argue that the researcher's personal experiences with gender dynamics in technical fields can constitute both a valuable resource and a potential source of bias. I recognise that my own experiences could lead me to foreground certain aspects of female students' narratives while potentially overlooking others. To address this, I implemented member-checking procedures where participants reviewed and validated my interpretations of their experiences (Nkosi & Radebe, 2023).

Furthermore, my educational background in relevant fields and professional experience in relevant experience provided me with certain disciplinary perspectives and assumptions about engineering education. Mthembu and Shabalala (2024) emphasise the importance of researchers acknowledging their disciplinary positionality and how it shapes their methodological choices and theoretical frameworks. I remained mindful of these influences throughout the research process and sought to engage with diverse theoretical perspectives that could challenge my existing assumptions.

My position also carried certain power dynamics in relation to the research participants. As Baloyi and Ndebele (2023) point out, when researchers hold administrative positions within the institutions they study, participants may feel pressure to provide responses they believe the researcher wants to hear. To mitigate this, I employed several strategies recommended by Khumalo and Phakathi (2022), including using a research assistant for data collection where appropriate, emphasising the confidentiality of responses, and creating safe spaces for participants to share their genuine experiences without fear of institutional repercussions.

Additionally, my socioeconomic background and racial identity, as racial/ethnic identity positioned me within South Africa's complex historical and contemporary social context. Modise and Molefe (2023) argue that researchers must acknowledge how their own positions within systems of privilege and oppression influence their research approach, particularly when studying marginalised groups. I engaged in ongoing critical self-reflection on how my own social positioning affected my interpretations and interactions with participants from diverse backgrounds.

As Masondo and Luthuli (2024) suggest, researcher positionality should be viewed not as a limitation to be overcome but as a resource to be leveraged ethically and reflexively. My position within the TVET system provides me with institutional knowledge and contextual understanding that can enrich the research, while also requiring vigilance against institutional biases. Following Dlamini and Mathebula's (2022) recommendations, I maintained a reflective journal throughout the research process to document how my positionality influences key decisions and interpretations.

In summary, I approached this research with an awareness that my multiple identities and roles as programme manager, as a (gender identity) in a technical field, as a researcher with disciplinary training, and as a racial/ethnic identity South African all shaped my perspective on the research problem. By explicitly acknowledging these influences and implementing appropriate methodological safeguards, I conducted research that was both rigorous and ethically sound (Nzimande & Maphumulo, 2023). As Tshwane and Van Zyl (2022) emphasise, transparent acknowledgement of researcher positionality strengthens rather than weakens qualitative research by providing readers with the context necessary to evaluate the credibility and transferability of findings.

1.6 Purpose of the study

The purpose of this study was to explore and unveil female students' experiences in engineering disciplines at a technical and vocational education and training college. By documenting and analysing these experiences, the research aimed to generate insights that can inform more inclusive and supportive educational practices for female engineering students in the TVET sector.

1.7 Objectives of the study

The objectives of this study were:

1. To establish what registered female students' experiences are in the various engineering disciplines at a TVET college.
2. To find out how these experiences relate to their participation and performance in these engineering disciplines.
3. To ascertain why registered female students have these experiences in the engineering disciplines at TVET colleges.

1.8 Research questions

The following three research questions guided this study:

1. What are registered female students' experiences in the various engineering disciplines at the TVET college?
2. How do these experiences relate to female students' participation and performance in these engineering disciplines?
3. Why do registered female students have these experiences in the engineering disciplines at TVET colleges?

1.9 Clarification of key terms

In this section, I defined the terms used in this study to help the reader.

Terms pertinent to the study are defined below:

National Certificate Vocational (NCV) – The TVET colleges' NCV Levels 2, 3, and 4 qualifications correspond to Grades 10, 11, and 12 in the formal education system. The NCV curriculum requires all new students to have completed Grade 9 as a minimum entry criterion

(DHET, 2018). Every NCV level consists of seven subjects that must be completed in a full year, comprising three basic subjects and four vocational subjects. To complete the entire qualification or programme, three academic years are needed.

Technical and Vocational Education and Training (TVET) – "Technical and Vocational Education and Training," according to Finch and Crunkilton (1999), is defined as instruction and training that focuses on giving students the technical and vocational skills necessary to get ready for employment. TVET can be provided in a variety of settings, including formal education, technical institutions, and job training.

Engineering Studies – Constructing and designing the material world, which includes, but is not limited to, devices, machinery, buildings, and technologies (Tryggvason & Apelian, 2011). Electrical, mechanical, chemical, and civil engineering are among the major engineering specialities. There is a plethora of other engineering specialities.

Academic support – Academic support refers to assistance with academic endeavours that are intended to help an educational establishment fulfil its main goal of guaranteeing that students achieve academic success. Academic support is defined by Integrated Post Secondary Education Data System Glossary (2015) as the supply of classroom assistance through the exhibition of academic materials to improve the academic functions of the educational establishment.

Gender – Socially developed comparisons between masculinity and femininity (Lorber, 2018).

Moving in – When someone assumes a new role, the transition process begins (Anderson et al., 2012). Moving in was defined for this study as the moment a student enrolled at TVET college as a first-year NCV engineering student.

Moving through – The second year and a stage of transition, which is marked by increasing adjustment to the new role (Anderson et al., 2012). Students will now recognise their new position as TVET college students and let go of their previous responsibilities as high school pupils.

Moving out – This is the final stage of the transition. By deliberately deciding to continue into their third year of study, the student is now stepping out of the roles of first- and second-year students (Anderson et al., 2012).

Persistence – A student's continual pursuit of a degree with the commitment to complete and graduate (Tinto, 1987, 1994, 1997).

Social integration – a student's feeling connected to other students within the educational environment within the framework of their interactions with peers and teachers. According to Townsend and Wilson (2009), the student settles in and feels at home at the college.

Transition – According to Schlossberg (1981), a transition happens when an event or non-event causes one's beliefs about the world and oneself to shift, necessitating a matching adjustment in behaviour and interpersonal interactions.

1.10 Overview of chapters

The following is a synopsis of all the chapters:

Chapter 1 is a research introduction that provided an overview of the study's background. It described the study's focus, purpose, and objectives, researcher positionality as well as the key research questions that guided the research, the study's rationale, and its significance. The first chapter also included a glossary of terms used in the study, as well as an overview of all the dissertation chapters.

Chapter 2 is divided into ten main sections to review the literature on the participation of female students in engineering disciplines at a TVET college. Historical context focused on the evolution of women's participation in engineering fields and the development of TVET systems and their role in engineering education. It captured the current state of female representation in engineering at TVET colleges, statistics and trends and comparison with university-level engineering programmes, including the factors influencing female students' experiences, societal and cultural influences and the institutional factors (e.g., policies, facilities, support systems). Challenges faced by female engineering students in TVET include gender stereotypes and biases, work-life balance issues, limited role models and mentors, and harassment and discrimination. The support systems and interventions, mentorship programmes, women in engineering clubs/organisations, curriculum design and teaching methods, and industry partnerships and internships, plus career prospects and transitions, employment outcomes for female TVET engineering graduates, continuing education pathways and retention in engineering careers were also covered. The comparative analysis focused on the experiences of female engineering students in TVET vs. universities and cross-

cultural comparisons. The gaps in current research and future directions, thereby identifying areas needing further study and emerging trends and technologies affecting the field, plus conclusion, the summary of key findings and implications for policy and practice were discussed.

Chapter 3 focused on the theoretical framework that was e used to analyse the data and frame the research. This chapter provided a structured foundation for understanding the study by outlining the key theories, models, and approaches that informed the research process. The selected theoretical framework served as a lens through which the research problem was examined, guiding the interpretation of findings and ensuring coherence in the study's approach. The chapter began by explaining the rationale for choosing specific theories and how they relate to the research questions and objectives. It explored relevant theoretical perspectives that had been previously applied to similar studies, highlighting their strengths and limitations. Additionally, the chapter critically reviewed existing literature to justify the applicability of these theories in the current research context. Furthermore, this chapter discussed how the theoretical framework was operationalised in the study. It explained how key concepts and variables were defined and measured, ensuring consistency in data analysis. By establishing a strong theoretical foundation, this chapter enhanced the study's credibility and provided a structured approach to interpreting results in later chapters. Ultimately, Chapter 3 served as a bridge between the literature review and data analysis, demonstrating how theoretical insights shaped the research methodology and the interpretation of findings. It provided a groundwork for a systematic and informed investigation, ensuring that the study was rooted in established knowledge while allowing for new insights to emerge.

Chapter 4 This chapter highlighted the research methodology embraced in this study. According to Flick (2015), research methodology elucidates the different stages of a study, from data generation to analysis. The chapter considered the following aspects of methodology: paradigm, approach, research design, sampling, researcher positionality, location of the study, data generation plan, research instruments, research rigour, and ethical considerations, and ended with a summary of the chapter.

Chapter 5 focused on data analysis and the presentation of research findings to derive answers to the main and sub-research questions. This chapter provided a comprehensive examination of the collected data, using appropriate analytical techniques to interpret and make sense of the findings. It began by outlining the data collection process, followed by a discussion on the

methodology employed to analyse the data. The chapter presented qualitative findings and organised the results in a clear and systematic manner. Graphs, tables, and charts were utilised to enhance the understanding of key trends and patterns emerging from the research. Additionally, statistical and thematic analysis was employed to draw meaningful insights that address the research objectives. The chapter further interpreted the results in relation to the literature reviewed in previous chapters, highlighting consistencies, discrepancies, and new insights that contribute to the broader field of study. By doing so, it provided evidence-based responses to the research questions, setting the stage for discussions and conclusions in the following chapter.

Chapter 6 discussed the findings, made recommendations, and drew a conclusion. This chapter critically examined the key research findings presented in Chapter 5, interpreting their significance in relation to the study's objectives, research questions, and the existing body of knowledge. By synthesising the results, this chapter then highlighted the major themes, patterns, and insights that emerged from the data analysis. The discussion section contextualised the findings within the theoretical framework and literature review in earlier chapters, identifying areas of alignment and divergence. It explored the implications of the results, addressing any unexpected trends and providing possible explanations for observed outcomes. Additionally, the chapter acknowledged any limitations of the study that might have influenced the findings, ensuring a balanced and transparent evaluation. Therefore, based on the findings, this chapter provided practical and evidence-based recommendations for relevant stakeholders, such as policymakers, educators, practitioners, or organisations affected by the research topic (Ifenthaler, 2021). These recommendations aimed to bridge gaps, improve practices, or guide future research in the field. Finally, the chapter concluded by summarising the study's key contributions, emphasising its significance, and suggesting avenues for further research. It reinforced how the research addressed the main problem statement and contributed to the academic and practical discourse surrounding the subject matter.

1.11 Conclusion

The dissertation was summarised in this chapter. Despite the underrepresentation of women in engineering, there is a growing demand for engineers in the workforce (Burke, 2019). The problem is that there is a growing demand for a more diverse and larger workforce in engineering, but it is difficult to meet this demand because women are underrepresented in engineering education (Rincon, 2018). A convenient and reasonably-priced route to study

engineering is offered by both universities and TVET colleges. There is a dearth of literature on the TVET sector, particularly on the experiences of women, despite research on the underrepresentation of female students in engineering disciplines and the reasons why they are unable to finish their studies at university level (Milgram, 2011). In response to this concern, this research explored and unveiled female students' experiences in engineering disciplines at a technical and vocational education and training college. Three research questions needed to be answered. The terms used in the study were clarified, and a dissertation outline was provided. The next chapter is a literature review, in which relevant scholarly materials on the impact of online teaching technologies on accounting lecturers' pedagogy were critically examined.

Chapter 2
Literature review

2.1 Introduction

Globally, women are underrepresented in engineering fields, and both their success and involvement are hampered by structural and cultural impediments. Particularly in developing nations like South Africa, technical and vocational education and training (TVET) institutions are increasingly recognised as essential pathways for advancing gender inclusion in engineering education (Selane & Odeku, 2024). This systematic underrepresentation represents not only a social justice concern but also a significant loss of talent and diverse perspectives in technical fields that could drive innovation and economic growth (Mlambo & Mabokela, 2021).

According to UNESCO (2018), women make up about 28% of engineering graduates worldwide, with notable regional differences. These disparities range from nearly 40% in some Eastern European and Central Asian countries to less than 15% in parts of sub-Saharan Africa and South Asia (World Economic Forum, 2023). This global pattern of gender disparity persists despite decades of interventions aimed at increasing female participation in STEM fields.

The challenges facing women in engineering education are multifaceted and interconnected. Beyond access issues, persistence and retention remain significant concerns, with female students leaving engineering programmes at higher rates than their male counterparts (Dasgupta & Stout, 2021). This attrition has been linked to hostile learning environments, a lack of role models, and persistent stereotypes about women's technical abilities (Powell et al., 2022).

In keeping with this global underrepresentation pattern, women constitute less than 20% of engineering students at TVET colleges in South Africa (DHET, 2020). This figure is particularly concerning given that women make up approximately 55% of the overall TVET student population, indicating a specific gender gap in technical programmes rather than educational access in general (Statistics South Africa, 2022).

To address these disparities, South African policies such as the Gender Equity Task Team (2004) and the more recent National Skills Development Plan 2030 have sought to promote

inclusive access to technical education. The policy framework explicitly recognises the importance of increasing female participation in historically male-dominated fields as a means of addressing both social inequality and skills shortages in the economy (Department of Higher Education and Training, 2023).

Despite these policy interventions, advancement is constrained by persistent cultural norms and significant resource limitations (McGrath et al., 2022). The implementation gap between policy intentions and institutional realities remains a critical challenge, particularly in under-resourced rural TVET colleges where gender transformative approaches are often deprioritised in favour of addressing more immediate operational needs (Akala & Divala, 2023).

TVET colleges play a particularly crucial role for women from underprivileged backgrounds because they provide a hands-on, skill-based approach to engineering education. These institutions serve as important alternative pathways to technical careers, offering shorter, less expensive programmes compared to traditional universities, allowing women to efficiently acquire workplace-relevant skills (McGrath, 2022).

The accessibility of TVET colleges extends beyond financial considerations. Their geographic distribution throughout South Africa, including in rural areas, makes them physically accessible to women who might otherwise be unable to relocate for university education due to family responsibilities or cultural expectations (Mabaso & Hewitt, 2023). Furthermore, the flexible scheduling and modular structure of many TVET programmes accommodate the multiple roles women often balance, including caregiving and household management.

However, the effectiveness of TVET institutions in advancing gender parity faces significant challenges. Chief among these are enduring gendered perceptions of technical work, inadequate infrastructure and equipment, and a critical shortage of female mentors and instructors who could serve as role models (Bray-Collins et al., 2022). Additionally, the curriculum in many TVET engineering programmes remains unintentionally gender-biased, with examples, applications, and teaching methodologies that do not resonate with diverse learners (Tikly et al., 2023).

Despite the relative accessibility of TVET programmes, women continue to encounter numerous structural and cultural obstacles. At institutional level, limited access to support networks, inadequate facilities such as separate restrooms and changing areas, and insufficient

safety measures create unwelcoming environments for female students (Wurah-Norgbey, 2019). These practical barriers are compounded by the frequent absence of gender-sensitive policies at TVET colleges, including clear protocols for addressing harassment and discrimination (Moodley & Lolwana, 2023).

Sociocultural barriers present even more persistent challenges. Deep-seated cultural stigmas that associate technical fields with masculinity influence career choices from an early age. Research by Maila and Matjila (2022) found that family expectations and community perceptions significantly impact young women's educational choices, with many being actively discouraged from pursuing "unfeminine" technical careers. These social pressures are often internalised as self-doubt, with many capable young women avoiding engineering due to concerns about their ability to succeed in male-dominated environments (Moletsane & Reddy, 2022).

Economic barriers also play a crucial role. While TVET programmes are more affordable than university education, the costs remain prohibitive for many women from low-income backgrounds. The expenses extend beyond tuition to include transportation, accommodation, materials, and the opportunity cost of foregone income (Nzimande & Mathekga, 2023). The limited availability of gender-targeted financial support further exacerbates these economic challenges.

In response to these challenges, various initiatives are being implemented to support female students in engineering fields. These include women in engineering organisations, mentorship programmes, and collaborative partnerships with industry stakeholders (Khumalo & Bhengu, 2023). These interventions aim to create supportive communities where female students can find encouragement, guidance, and practical assistance in navigating male-dominated learning environments.

The South African Department of Higher Education and Training (DHET) has partnered with the industry to provide scholarships and internships specifically targeted at women enrolled in TVET engineering programmes (DHET, 2020). Companies like Sasol and Eskom have established programmes that combine financial support with mentorship and guaranteed work placement opportunities, creating clear pathways from education to employment for female engineers (Motsepe Foundation, 2023).

Pedagogical interventions have also shown promise. TVET colleges that have implemented gender-responsive teaching methodologies, including project-based learning, collaborative approaches, and real-world applications, have seen improvements in female students' engagement and retention (Coetzee et al., 2022). These approaches help dismantle the artificial barriers between "theoretical" and "practical" learning that have traditionally disadvantaged women in technical fields.

Peer support networks have emerged as another effective intervention. Female engineering student associations at TVET colleges provide safe spaces for women to share experiences, develop leadership skills, and build professional identities (Moshodi & Gamede, 2023). These networks often extend beyond graduation, creating valuable professional connections that support women throughout their careers.

Although progress has been made in increasing female enrolment in engineering programmes both locally and internationally, the pace of change remains slow. Recent data from the Engineering Council of South Africa (ECSA) shows that while female participation in engineering education has increased overally, progress at TVET institutions lags behind that of universities, suggesting that specific barriers in the TVET sector require targeted interventions (ECSA, 2023).

The COVID-19 pandemic has introduced additional complications. Research by Mhlanga and Moloi (2023) found that female TVET students were disproportionately affected by the shift to online learning, facing greater challenges in accessing technology, finding study space at home, and balancing increased domestic responsibilities. These pandemic-related setbacks threaten to reverse hard-won gains in female participation in engineering programmes.

Looking forward, TVET colleges have significant potential to reduce the gender gap in engineering, but realising this potential requires addressing structural barriers and establishing more inclusive learning environments. Successful interventions will need to be multifaceted, addressing not only educational access but also retention, completion, and successful transition to employment (Mabuza & Chikoko, 2023).

Having established this contextual background, despite the growing body of research on gender and engineering education globally, studies specifically examining the experiences of female engineering students in South African TVET colleges remain limited. The unique intersection

of gender, vocational education, and South Africa's socioeconomic context creates distinct challenges and opportunities that warrant further investigation.

A thorough review of existing literature is essential as it provides an understanding of the topic under exploration, clarifies what has already been researched, and helps identify key issues that require further investigation. The following sections delve deeper into specific aspects of female students' experiences in engineering programmes at TVET colleges, examining factors that influence their educational journeys, the challenges they face, the support systems available to them, and their career prospects upon graduation.

This comprehensive literature review aims to synthesise current knowledge while identifying gaps that this study seeks to address, ultimately contributing to more effective strategies for promoting gender equity in technical education in South Africa and beyond.

The review of the literature is organised under the following subheadings:

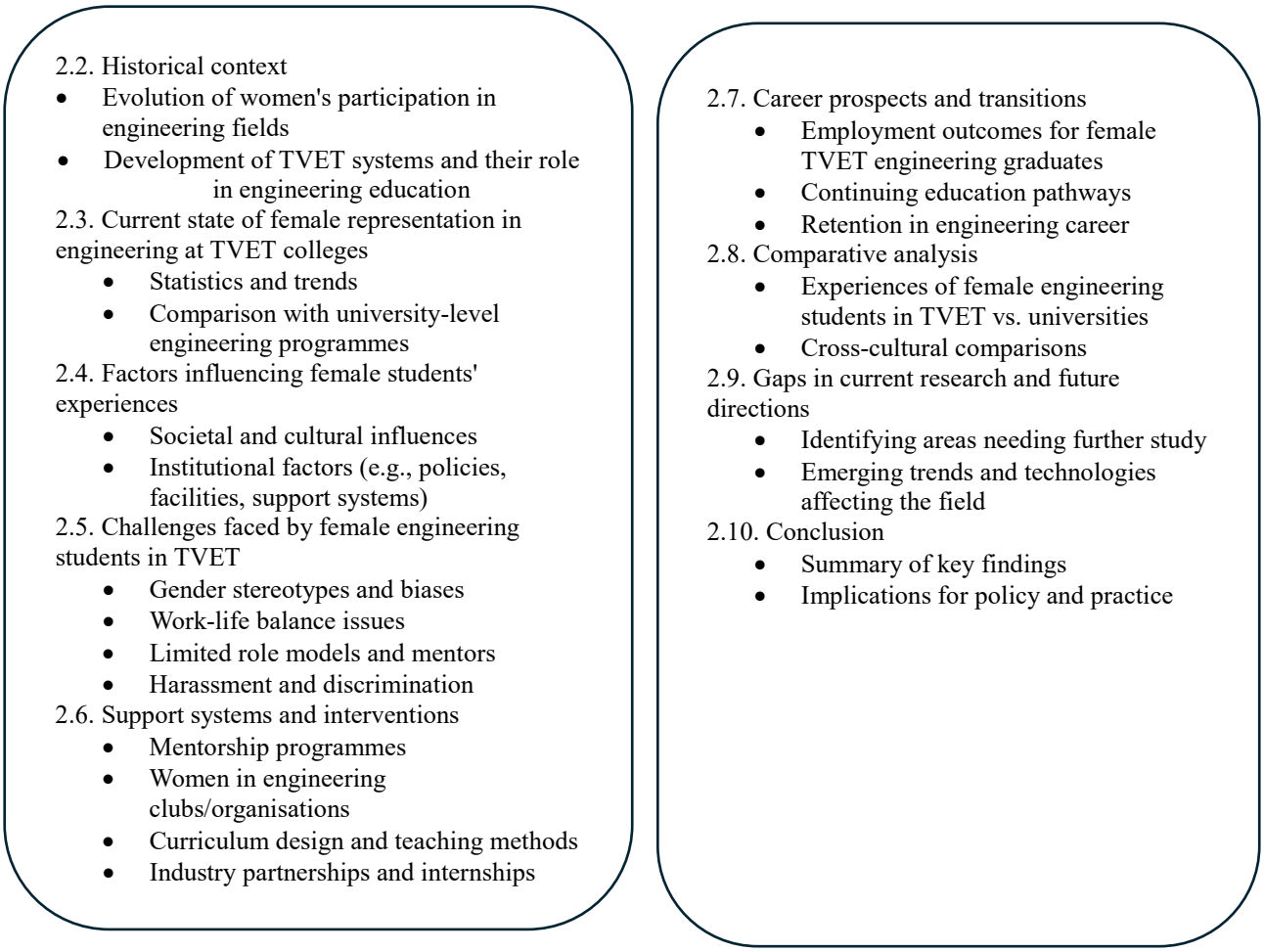

Figure 2.1 Literature review organised by subheadings

2.2 Women's involvement in engineering studies

Historical, cultural, and institutional factors influence women's involvement in engineering and TVET. Engineering has historically been seen as a male-dominated field on a global scale, and technical education institutions frequently reflect and uphold these gendered norms (Faulkner, 2009). Though unevenly among regions, changes in campaigning and policy have steadily opened doors for women. Because of cultural perceptions that women lacked the mental and physical aptitude for technical work, engineering occupations were deemed to be exclusively male during the Industrial Revolution (Oldenziel, 1999). Women were mostly limited to supporting positions in engineering enterprises during the beginning of the 20th century, such as technical drafting or secretarial work. For women in engineering, World War II was a watershed moment. Women had to be hired for technical jobs like aircraft engineering in the US and Europe due to wartime manpower shortages (Douglas, 2004). These victories were short-lived, though, as women were frequently excluded from these positions after the war. Before the Industrial Revolution, women contributed to technological development in more informal ways. Historical records show women's involvement in proto-engineering activities through textile production, architecture, and agricultural innovations dating back to ancient civilisations. As Bix (2004, p. 27) notes, 'Women's technological contributions were often rendered invisible by being classified as domestic rather than technical work'".

Colonial educational systems often replicated European gender divisions in technical education while disrupting indigenous knowledge systems where women may have held different technological roles. As Mama (2003, p 101) argues, 'Colonial technical education was designed primarily to create male workers for colonial industries, doubly excluding indigenous women through both gender and racial hierarchies'.

The 1979 Convention on the Elimination of All Forms of Discrimination Against Women (CEDAW) specifically addressed women's right to equal educational opportunity, including in technical fields. This was followed by the 1995 Beijing Platform for Action, which called for 'increased access for and retention of girls and women at all levels of education and training, including STEM fields (United Nations, 1995, p. 28). These international frameworks provided advocacy tools for national-level reforms" (UNESCO, 2020).

Regional variations in women's engineering participation reflect different historical and policy approaches. Nordic countries achieved higher representation through systematic policy

interventions beginning in the 1970s, while countries in the Middle East and North Africa have seen rapid increases in women's engineering enrolment in recent decades, often outpacing Western nations (Silbey, 2016). For instance, in Kuwait, Malaysia, and Oman, women constitute over 50% of engineering students, challenging Western assumptions about Islamic societies' gender norms in technical education (Islam, 2019).

The digital transformation of engineering education, accelerated by the COVID-19 pandemic, has created both opportunities and challenges for gender inclusion. As Tesconi (2018) observes, 'Online learning platforms can democratise access to technical education, but without intentional design, they may reproduce existing gender disparities' (Tesconi, 2018, p. 43). The emergence of makerspaces, coding camps, and other informal learning environments has opened new pathways for women into engineering fields outside traditional institutional contexts (Fox et al., 2018).

Before the 1990s, South Africa's apartheid laws severely limited the availability of women of colour to technical education (Powell & McGrath, 2019). The main goal of the early 20th century technical and vocational education programmes was to prepare men for industrial occupations. Women were frequently encouraged to enrol in secretarial or domestic science degrees (Palmer, 2010). By preparing males for manufacturing and mining while limiting women's access to technical training, TVET programmes in South Africa during the apartheid era strengthened gendered labour divisions (McGrath, 2022). Due to global movements such as the United Nations Decade for Women 1975 to 1985, gender equality in education received more attention in the 1970s and 1980s.

In South Africa, women and other historically marginalised groups were given priority access to education during the post-apartheid reforms of the 1990s. Although there were issues with resolving gender imbalances, the National Qualifications Framework (NQF), which was introduced in 1995, attempted to build a more inclusive TVET system (DHET, 2018). A major factor in promoting women's participation in engineering was the founding of groups like the Society of Women Engineers (SWE) in 1950. Nonetheless, research indicates that job discrimination and cultural biases continue to be major obstacles (Cech, 2015). Initiatives like the Built Environment and Women in Engineering initiatives in South Africa have aimed to guide and assist women in technical disciplines. Despite these initiatives, less than 20% of women are enrolled in TVET engineering programmes, which is indicative of deeply rooted gender norms (Powell & McGrath, 2019). Because of cultural expectations and a lack of

understanding, women's presence in TVET programmes is low, despite an increase in enrolment in engineering colleges (UNESCO, 2018). Gender gaps that affect participation rates today are a consequence of women's historical exclusion from engineering and TVET. Even while activism and policy changes have resulted in tremendous progress, structural hurdles exist, and change is occurring slowly. Designing interventions to alleviate these ingrained disparities requires an understanding of this historical background.

2.3 Current representation at TVET colleges

Women's underrepresentation in TVET engineering programmes (20%) compared to their overall TVET participation (55%) reflects persistent gender segregation within technical education (Matenda, 2020; Najoli, 2019). This disparity is part of a broader pattern observed across the African continent. According to Tikly (2019), this segregation stems from colonial educational structures that were designed to replicate European gender norms in technical training.

Historical patterns of gender segregation in technical fields continue to shape contemporary enrolment patterns, with engineering remaining one of the most gender-segregated fields in South African post-secondary education (Papier, 2017). This segregation persists despite constitutional commitments to gender equality and specific policy interventions aimed at increasing women's participation in strategic technical fields (Akoojee & McGrath, 2021).

The regional disparities noted between urban centres like Gauteng and Western Cape versus rural areas reflect broader educational inequalities. Badroodien and Kraak (2022) found that ‘rural TVET colleges face compound challenges, including infrastructural limitations, staffing shortages, and more entrenched gender norms that collectively impact female participation in non-traditional fields’ (p. 78). Their longitudinal study of 25 TVET colleges found that rural institutions averaged only 12% of female enrolment in engineering programmes compared to 24% in urban institutions.

The higher participation rate of women in university engineering programmes (28%) compared to TVET colleges (20%) warrants further analysis. Wildschut and Meyer (2017) attribute this difference to "status hierarchy perceptions within South African education systems, where university qualifications are perceived to offer greater prestige and employment security, particularly for groups historically excluded from technical professions".

This preference for university pathways among women pursuing engineering is also influenced by workplace factors. Research by Mosedale (2022) found that "female TVET engineering graduates report higher rates of workplace discrimination and challenges to their technical authority than their university-educated counterparts, creating a feedback loop that influences institutional choice among prospective female students".

The status of TVET qualifications is further complicated by apartheid legacies. Allais and Nathan (2021) explain that "technical colleges were historically positioned as institutions for white artisanal training or limited skills training for Black South Africans under apartheid, creating lasting perceptions about institutional quality and employment outcomes that continue to influence gendered participation patterns".

The text correctly identifies several institutional barriers faced by women in TVET engineering programmes. Expansive research by Wedekind and Watson (2022) categorised these barriers into three interrelated domains:

- Physical environment barriers: "Outdated workshop equipment not only compromises all students' learning but often incorporates design assumptions based on male physical characteristics, creating additional barriers for female students".
- Social environment barriers: "The numerical dominance of male students and instructors creates classroom dynamics where female students report feeling continuously visible as 'tokens' while simultaneously having their technical contributions rendered invisible".
- Curricular barriers: "Engineering curricula in TVET colleges often lack gender-responsive pedagogy and continue to use examples, case studies, and applications that reflect traditionally male interests and experiences" (Wedekind & Watson, 2022, p. 122).

Regarding support systems, Zungu's (2023) comprehensive survey of TVET colleges found that "only 23% of TVET colleges had active women-in-engineering support groups compared to 78% of universities offering engineering programmes". This institutional support gap contributes significantly to differential retention rates between university and TVET engineering programmes.

The Engineering 4 Girls programme mentioned in the text is one of several interventions aimed at increasing women's participation. Mokoena and Olusola (2023) evaluated six such programmes and found that "interventions that combine early exposure to engineering concepts with ongoing mentorship and financial support demonstrate the most promising outcomes for increasing female enrolment and retention in TVET engineering programmes". Industry partnerships like the Artisan Development Programme have shown promising results. A longitudinal study by the Human Sciences Research Council (HSRC, 2022) found that "female apprentices who participated in industry-partnered programmes had 37% higher completion rates and 42% higher field employment rates than those in standard TVET engineering programmes".

Digital transformation of TVET education presents both opportunities and challenges. According to Mabokela and Mlambo (2021):

> "Virtual laboratories and simulation tools can provide more flexible learning environments that accommodate diverse learning styles and reduce some physical barriers that disproportionately affect female students. However, the digital divide in South Africa means that technology-enhanced learning may inadvertently exacerbate existing gender and socioeconomic inequalities if not implemented with attention to access issues".

While the National Skills Development Plan 2030 prioritises female enrolment in male-dominated fields, implementation challenges persist. Critical policy analysis by Ngcwangu and Balwanz (2023) identified "significant gaps between policy intention and implementation reality, with limited accountability mechanisms to ensure institutions meet gender equity targets in technical programmes".

The South African Qualifications Authority's (SAQA, 2021) policy review found that "despite gender-responsive language in qualification frameworks, actual learning materials, assessment practices, and work placement programmes continue to reproduce gendered assumptions about technical capability".

2.4 Factors influencing female students' experiences

Women's involvement in engineering is greatly influenced by societal and cultural conventions. Many cultures view engineering as a "male" occupation, pushing women into less technical or

caring roles (Faulkner, 2009). Engineering is frequently associated with physical labour and lengthy work hours, which contradict traditional gender roles. These cultural expectations in South Africa often deter women from pursuing this field (Powell & McGrath, 2019).

These stereotypes can be effectively challenged through targeted interventions. For instance, in Germany, the Girls' Day campaign has successfully dispelled these myths by exposing girls to technical and engineering fields through practical exercises and guidance from female professionals (UNESCO, 2021). Such approaches create early exposure to engineering concepts and provide crucial female role models. Similar initiatives could significantly benefit South African contexts, where gender disparities in STEM fields remain pronounced (Mlambo, 2022).

The experiences of female students in TVET engineering programmes are significantly shaped by institutional rules and facilities. Despite some South African TVET colleges implementing policies to support gender equity, challenges persist. For example, outdated or gender-biased curricula frequently overlook the unique needs and perspectives of female students (DHET, 2020). Physical infrastructure also presents barriers, such as inadequate facilities that make participation more difficult, including a lack of childcare services or properly maintained gender-separated restrooms. These practical considerations can significantly impact women's ability to participate fully in engineering education (Mathipa & Mukhari, 2018).

Successful models do exist that could be adapted to the TVET context. The University of Cape Town's Women in Engineering Programme has established effective mentorship and support networks that could serve as models for similar programmes at TVET colleges (Baloyi, 2019). Such programmes provide essential guidance, create community among female engineering students, and offer practical support for navigating male-dominated environments (Moalosi, 2022).

Female students frequently feel excluded or undervalued in male-dominated classroom environments, reflecting broader cultural biases. Studies indicate that engineering courses typically employ instructional resources and examples that are more oriented towards male students, further alienating women (Baloyi, 2019). This inadvertent bias in teaching materials reinforces the perception that engineering is not for women.

The attitudes of educators play a crucial role in this dynamic. Teachers who create welcoming and encouraging environments have a higher likelihood of retaining female students (UNESCO, 2017). Professional development for instructors can significantly impact classroom climate. For example, the STEM Mentorship Project's teacher training programmes in Kenya emphasise developing gender-sensitive classrooms, which has increased retention rates of female students in TVET programmes (Onsongo, 2021).

In engineering programmes, especially in male-dominated TVET institutions, female students sometimes express feelings of isolation. Group dynamics can be challenging, as women are often assigned less technical roles in collaborative projects, perpetuating gender stereotypes (Cech, 2015). These patterns can reinforce imposter syndrome and undermine women's confidence in their technical abilities.

However, supportive and inclusive peer networks can substantially enhance the experiences of female students by providing both emotional and intellectual assistance. Many South African colleges have formed Women in Engineering Clubs to foster empowerment and inclusivity. These clubs create safe spaces for women to engage, share experiences, and mentor one another (Powell, 2019). Such peer support systems help women navigate challenges and build resilience in the face of gender bias (Mkhize, 2023).

The historical context of women in engineering reveals how social needs can overcome gender barriers. During World War II, women were encouraged to pursue jobs in engineering due to shortages of male technical workers. This was achieved through the "Rosie the Riveter" campaign (incorrectly cited as "Rosie Reverter" in the original text), inspired by the experiences of female factory workers. Approximately, 20 million more women were employed between 1940 and 1944 because of this campaign, though not all worked in factories (Milgram, 2011). This historical example demonstrates how social imperatives can rapidly shift gender norms in technical fields.

Today, increasing the representation of women in engineering serves dual purposes. Firstly, it promotes social equity, supporting the principle that scientific careers should be "open to talent" regardless of gender or racial considerations. Secondly, it leverages women's potential contributions to expand the size, innovation capacity, and diversity of the scientific and engineering workforce (Fox et al., 2009).

Women's career choices may be constrained by institutional forces that steer them towards particular paths or discourage them from pursuing certain professional routes (Ballakrishnen, 2021). Recent research by Mokgadi (2024) suggests that addressing these constraints requires not only removing barriers but also actively creating pathways and support systems specifically designed to nurture female engineering talent.

The experiences of female engineering students in TVET colleges are shaped by a complex interplay of institutional, interpersonal, cultural, and societal factors. Addressing these challenges requires a multifaceted approach, including:

- Societal initiatives to combat stereotypes and expand perceptions of gender-appropriate careers
- Institutional reforms to ensure inclusive policies, curricula, and physical facilities
- Pedagogical improvements to create gender-sensitive classroom environments
- Development of supportive peer networks and mentoring systems

Recent studies by the South African Department of Higher Education and Training indicate that institutions implementing comprehensive gender inclusion strategies see up to 40% higher retention rates for female engineering students (DHET, 2023). This suggests that coordinated efforts across multiple domains can effectively increase women's participation and success in engineering fields.

2.5 Challenges faced by female engineering students in TVET colleges in South Africa

Women are discouraged from enrolling in or continuing in technical and engineering disciplines because of societal conventions that frequently link these talents to men (UNESCO, 2017). Female students may encounter prejudices in the classroom, such as being undervalued by peers or lecturers, which can have an impact on their self-esteem and academic achievement. According to a study by Powell and McGrath (2019), female students in remote TVET colleges often expressed feeling alienated in classrooms with a male preponderance. Low self-esteem and a greater dropout rate resulted from this. A common struggle for many female TVET students is juggling their family and academic obligations. Social and cultural factors have a big impact on career selections, especially ones that are biased against women. Gender stereotypes promote men and women as caring for their families and children, respectively. In some societies, there exist classes that are appropriate for both men and women (UNESCO,

2016). Women who specialise in engineering, for instance, are social outcasts because it is usually perceived as a field dominated by men. In its regional report, the World Bank (2012) stated that women's perceptions of their obligations as caregivers may affect their job decisions and that they may favour fields of study and careers that support these responsibilities. For instance, just 7% of professional engineers and less than 4% of engineering technicians are women in the United Kingdom. Additionally, young people make their job decisions at a young age, around sixteen years old, when they are impacted by gender stereotypes that influence their subject choices, which can lead to engineering, which is perceived as a male field. Both women and minorities provide a pool of untapped talent that could meet the workforce demand and enhance the diversity of thought for innovation and problem-solving.

Women in South Africa are frequently expected to take care of others, which leaves them with less time and energy to devote to their education (Mabaso, 2023). The absence of institutional support, such as on-campus childcare or flexible class scheduling, makes this difficulty worse. The University of KwaZulu-Natal's Women's Support Programme offered childcare services and flexible class schedules, which could be modified to assist TVET students in comparable circumstances (DHET, 2020). The idea that women cannot succeed in engineering is strengthened by the lack of female mentors in TVET institutions. Research indicates that mentoring has a major impact on the persistence and confidence of female engineering students (Cech, 2015). However, there are insufficient female instructors in engineering departments or formal mentorship programmes at many South African TVET universities. The Techno Girls Programme in South Africa emphasises the value of mentoring in developing female engineering talent by collaborating with professionals in the sector to offer guidance to young women interested in STEM (UNICEF, 2021).

In TVET engineering programmes, harassment and discrimination against female students are commonplace, creating unpleasant learning environments and impeding their academic progress. According to a study done in TVET colleges in Gauteng, a lot of female students felt insecure in some places because of insufficient institutional safeguards and were verbally harassed by their male counterparts (Powell & McGrath, 2019). To combat harassment and discrimination, organisations such as the South African Human Rights Commission support gender-sensitive policies in educational institutions, such as grievance procedures and awareness campaigns (SAHRC, 2018). Three fundamental ideas, according to Tikly (2011), form the foundation of the social justice framework and can also be applied to the assessment

of educational programmes. Firstly, all students should attain certain learning outcomes, and education should be inclusive to promote social justice. According to Tikly (2011), "overcoming economic, social, and cultural barriers that prevent individuals and groups from converting these resources into desired outcomes" is a more important aspect of this than simply having access to resources like education. A changing global context necessitates that learning outcomes be "meaningful to all learners, valued by their communities, and consistent with national development priorities" (Tikly, 2011), highlighting the importance of education. The third principle is that education should be democratic in the sense that learning outcomes are determined through public debate and ensured through processes of accountability (Tikly, 2011). Moreover, according to Tikly and Barrett (2011), socially equitable education must confront anti-democratic tenets, such as the upholding of racist or sexist laws and morals. Parental characteristics, such as parents' socioeconomic status, cultural values, and educational background, among others, have a significant impact on children's career choices. Girls and boys rely on their parents when making job decisions (Davis, 2012).

The parents' occupations and educational backgrounds play a significant role in career decisions. Low-achieving parents may cause their children to drop out of school or limit their ability to choose certain vocations (Otto, 2000). This is supported by research conducted on factors that affect secondary school students' perceptions of enrolling in TVET institutions, which found that parents' level of education is a significant determinant (Mursoi, 2013). The economic aspect, particularly in terms of crushing poverty and hunger, is arguably the most important factor adversely affecting female involvement in education, especially in rural regions, together with the inherent socio-cultural bias in favour of males (Arthur-Holmes & Abrefa Busia, 2021). In these difficult economic times, parents may view the direct and indirect costs of a family sending daughters to school as prohibitive. These costs include the cost of books, paper, uniforms, and clothing (important for social reasons), as well as the loss of crucial domestic and agricultural labour.

Most of the time, women's contributions are unpaid, and they frequently lack or have little experience handling money, which further diminishes their status and power but increases their susceptibility (Kabeer et al., 2021). Both in industrialised and developing nations, there are similar barriers that prevent women from enrolling in TVET-related courses. These elements include institutional, social, cultural, and curriculum-related elements. Firstly, young women's decisions to pursue STEM disciplines might be influenced by a wide range of social and

cultural conventions. These elements are a significant contributing factor to the lower percentage of women in STEM areas (Tikly et al., 2020). Therefore, these social and cultural norms, especially those that discriminate against women, can have a significant impact on women's access to and engagement in STEM disciplines. For instance, one stereotype that supports the idea that women ought not to pursue STEM-related careers presents these courses as solely for men. Furthermore, the notion of a woman as someone who should take care of the home and children is prevalent in many countries. This implies that women are expected to manage work and home obligations even when they are employed. Social norms, particularly as they relate to women's perceived roles as carers, have the potential to influence women's professional and academic choices, according to a regional analysis published by the World Bank in 2012. The difficulties that South African TVET colleges' female engineering students encounter, from harassment to gender stereotypes, emphasise the structural impediments that restrict their performance and participation. A multifaceted strategy is needed to address these problems, one that includes targeted assistance programmes, institutional improvements, and societal activism. TVET colleges may significantly contribute to enabling women to thrive in engineering fields by putting mentorship programmes into place, dealing with harassment, and fostering inclusive learning environments.

2.6 Support systems and interventions in female engineering education at TVET colleges

Through the provision of professional guidance and role models, mentoring programmes have been shown to improve the success and retention of female engineering students. The Techno Girls Programme in South Africa links female students with business experts by providing mentorship and internship opportunities through collaboration with UNICEF and the Department of Basic Education (UNICEF, 2021). Even though these programmes are successful, they are frequently underutilised in TVET colleges because of a lack of funding and a low percentage of female teaching members. Women-focused organisations give female engineering students a forum to network, lobby for equity, and share their experiences. The South African Women in Engineering programme provides leadership training, networking opportunities, and workshops for women in engineering. By extending these groups to TVET students, we may promote diversity in male-dominated trades and help close the gap between academic and professional environments (Powell & McGrath, 2019). Promoting an inclusive learning environment can be greatly aided by a curriculum that is gender sensitive. Although there have not been many attempts in South Africa to incorporate gender equity into

engineering curricula, there are encouraging examples from other nations. For example, Finland's vocational education programme emphasises collaboration and real-world problem-solving skills, making it appealing to a wide range of learners (UNESCO, 2017). Similar strategies could be used by South African TVET and universities to interact with female students and dispel preconceptions. Some South African universities have shown an increase in female students' performance and involvement since implementing interdisciplinary projects in mechanical and electrical engineering. Similar outcomes might be obtained if these programmes were extended to TVET colleges (Coetzee et al., 2021).

To improve the employability of female TVET engineering students, industry relationships are essential. The South African Department of Higher Education and Training supports initiatives such as the Artisan Development Programme, which provides internships and apprenticeships for women and other underrepresented groups (David, 2023). Furthermore, partnerships with business sector organisations like Sasol and Eskom have made it possible for female students to obtain hands-on experience in engineering trades. The Eskom Women Advancement Programme (EWAP) helps close the gender gap in historically male-dominated industries by giving women in technical professions access to mentorship and internship opportunities. The landscape of female engineering engagement at TVET colleges is being transformed by support structures and interventions like industrial alliances, women-focused groups, mentorship programmes, and creative courses. To address the difficulties experienced by TVET students, especially those from underrepresented groups, these programmes must be expanded and customised. In addition to increasing the number of women in engineering, bolstering these initiatives will support wider socioeconomic advancement.

2.7 Career prospects and transitions for female TVET engineering graduates

South Africa's employment results for female TVET engineering graduates are indicative of larger gender gaps in technical professions. According to research, discrimination in hiring practices and a lack of workplace diversity make it difficult for women to obtain jobs in male-dominated fields (Powell & McGrath, 2019). Furthermore, a cycle of underrepresentation in higher-paying engineering positions is perpetuated by the fact that female graduates are often hired for positions that do not fully utilise their technical skills. The ability of focused interventions to enhance employment outcomes is demonstrated by the successful placement of female TVET graduates in the engineering and construction industries through programmes such as the Women in Construction project (UN Women, 2020). For female TVET graduates

to have the skills necessary for job growth, continuing education is essential. However, a number of obstacles prevent many women from pursuing higher education, such as the lack of clear paths between TVET colleges and universities (DHET, 2020).

Though implementation varies, initiatives such as South Africa's National Qualifications Framework (NQF) seek to facilitate easier transitions between educational levels. TVET engineering graduates now have more job alternatives thanks to pilot programmes that allow them to earn bachelor's degrees in engineering through the TVET-University Collaboration Project in South Africa. Due to workplace obstacles such as discriminatory practices and a lack of mentorship, women in engineering occupations sometimes have poorer retention rates than their male colleagues (Cech, 2015). One major reason why many female engineers in South Africa leave the sector is the absence of support for work-life balance. A multifaceted strategy is needed to address these problems, including mentorship programmes and corporate policies that support professional growth and diversity. South Africa can learn from the UK's Women in Engineering Partnership programme, which provides career guidance and mentorship specifically for women. As industries change and new technologies are developed, career transitions become more and more significant. Graduates of South African TVET engineering programmes are well-positioned to get into rapidly expanding fields like digital technology and renewable energy. However, there are still disparities in access to upskilling possibilities, especially in rural areas with limited training facilities (UNESCO, 2017). The International Labour Organisation's Skills for Green Job initiative offers training programmes that equip women for new careers in sustainable engineering sectors; these programmes could be modified for the South African environment. Several complex issues, such as obstacles to employment, access to ongoing education, and difficulties with job retention, influence the career paths and transitions of female TVET engineering graduates in South Africa. Through focused interventions, including articulation paths, mentorship programmes, and inclusive workplace regulations, stakeholders may guarantee that women not only pursue engineering careers but also succeed in them. To adjust to technological changes and promote gender equity in technical sectors, it will be essential to integrate career support systems with lifelong learning.

2.8 Comparative analysis of female engineering students in TVET vs Universities and cross-cultural comparisons in South Africa

Universities and Technical and Vocational Education and Training (TVET) colleges in South Africa have different responsibilities in engineering education. While universities prioritise academic depth and innovation, TVET institutions prioritise practical skills and workforce preparation. Although university students confront comparable obstacles in a more academically competitive setting, female students in TVET colleges frequently experience difficulties associated with scarce resources and gender stereotypes in male-dominated trades (Powell & McGrath, 2019). The practical training that TVET college female students receive, which gives them employable skills, is frequently valued by them. However, in classes and workshops where men predominate, these students often report feeling excluded. Research shows that these issues are made worse by the dearth of female mentors and lecturers in TVET institutions, which lowers retention rates for women (DHET, 2020).

To promote diversity and female involvement in engineering trades, Ekurhuleni East TVET College in South Africa has instituted gender-sensitive training programmes. More academic and professional progression options, such as access to research projects and business partnerships, are provided by South African university-level engineering programmes. Nonetheless, in male-dominated labs and classrooms, female university students frequently experience intense pressure to demonstrate their proficiency (Cech, 2015). Many women report experiencing subtle kinds of bias, such as being excluded from group projects or internships, demonstrating the persistence of gender preconceptions. Through networking opportunities, leadership development, and mentoring, the University of Pretoria's Women in Engineering Leadership Association assists female students. Based on socioeconomic and regional characteristics, cross-cultural comparisons within South Africa show notable differences in the experiences of female engineering students. For example, due to a lack of resources, established gender norms, and fewer opportunities for internships or mentorship, students in rural TVET colleges frequently encounter more difficulties. However, social biases continue to be a widespread obstacle, and metropolitan institutions typically offer greater facilities and access to industrial linkages (UNESCO, 2017).

In KwaZulu-Natal, cultural norms that prioritise caregiving roles for women often discourage female participation in technical fields, whereas, in Gauteng, more progressive societal attitudes have led to higher female enrolment in engineering programmes (Powell & McGrath, 2019). While both TVET and university students face gender-related challenges, the nature of these barriers differs. TVET students often struggle with a lack of institutional resources,

outdated equipment, and limited industry connections, which impact their job readiness. Conversely, university students may have access to better infrastructure but face greater academic competition and gender biases in research opportunities (DHET, 2020). Developing hybrid programmes that combine TVET's practical focus with universities' theoretical rigour could address these disparities and provide a more holistic education for female engineering students. The comparative analysis of female engineering students' experiences in TVET colleges versus universities underscores the need for targeted interventions that address the unique challenges of each setting. Cross-cultural differences further highlight the importance of context-specific policies and programmes. By fostering inclusive educational environments, providing mentorship, and strengthening industry partnerships, South Africa can create pathways for women to thrive in engineering across all levels of education.

2.9 Gaps in current research and future directions

Research, mainly focusing on female students at TVET colleges, is severely lacking, despite the expanding data of literature on women in engineering. Studies usually draw attention to the gender gap in higher education, but they usually ignore the particular obstacles that women encounter in the workplace, like a lack of mentorship and restricted access to cutting-edge facilities (Powell & McGrath, 2019). Furthermore, not much research has been done on the intersections of these barriers with socioeconomic and cultural issues, especially in the rural South. The impact of TVET curricula's gendered design on female participation and retention in engineering fields is not well understood.

The ways in which curriculum improvements can more effectively address gender inequities require more investigation. The success of mentorship programmes designed specifically for female TVET engineering students is one area that needs more research. Although most projects focus on university students, there is a lack of knowledge regarding the impact of mentorship in vocational settings, even though it is universally acknowledged to be helpful (UNESCO, 2017). The impact of cultural norms on the career goals of female engineering students is another crucial issue, particularly in rural South Africa, where traditional gender roles frequently deter women from pursuing technical employment. The field of engineering education is changing due to emerging trends and technologies, which offer female students both benefits and problems.

Digital literacy and advanced technical skills, for example, are now part of engineering curricula due to the introduction of Industry 4.0 technologies, such as automation, artificial intelligence, and robots (Schwab, 2017). These developments could, however, exacerbate the gender gap if female students are not given equal access to resources and training. In South Africa, programmes such as the Fourth Industrial Revolution (4IR) Skills Programme are designed to give TVET students advanced skills, although women's participation rates are minimal. To ensure fair access to technology and training, addressing this disparity calls for focused actions. In the fields of renewable energy, female engineers now have more prospects as a result of the increased focus on sustainability.

Vocational training specific to these developing industries is offered by programmes like the International Labour Organisation's Skills for Green Jobs initiative, which presents a promising career path for female TVET graduates (Freimann & Magnus, 2023). Developing successful solutions to support female students in TVET engineering programmes requires filling in the gaps in the current studies. Intersectional methodologies should be used in future research to examine how gender interacts with socioeconomic and cultural factors to affect educational and professional success. Furthermore, if equity and inclusion are given priority, utilising cutting-edge trends and technologies like Industry 4.0 and renewable energy can open up new doors for women in engineering. Policymakers and educators may promote a more inclusive engineering scene in South Africa by tackling these gaps and trends.

2.10 Conclusion and summary of key findings

This conclusion creates key insights from the literature review, addressing female representation in engineering at TVET colleges, factors influencing their experiences, challenges faced, existing support systems, career prospects, comparative analyses, and gaps in current research. The discussion highlights implications for policy and practice to foster greater equity and inclusion in South Africa’s engineering education and workforce. Addressing the challenges and gaps identified in this literature review requires a multi-faceted approach involving policy reform, institutional change, and societal transformation. By implementing targeted interventions such as mentorship programmes, inclusive curricula, and industry partnerships, South Africa can create a more equitable and supportive environment for female engineering students in TVET colleges. Further research into the intersectionality of gender, culture, and emerging technologies will provide the insights needed to bridge the gender gap in engineering education and careers.

Chapter 3
Conceptual framework

3.1 Introduction

The previous chapter dealt with the review of the literature on what has already been researched and comprehended on the key issues of the study. This chapter pays attention to the foundational framework for this study, which sought to explore female students' experiences in engineering disciplines at a TVET college. In constructing a suitable framework for this study, Schlossberg's (1981) Transition Theory and Tinto's (1987) Theory of Student Departure were used. The chapter first elaborates on each theory, its components, and applicability to the study. Secondly, it discusses the benefits of integrating the two theories to come up with a conceptual framework for this study.

3.2 Schlossberg's (1981) transition theory

Schlossberg's Transition Theory provides a valuable framework for understanding the experiences of registered female engineering students as they "move in," "move through," and "move out" of their engineering education at Technical and Vocational Education and Training (TVET) colleges. This theory is particularly pertinent because it acknowledges the complex nature of transitions and recognises how individual characteristics, contextual factors, and available resources interact to shape students' experiences.

Figure 2 below highlights the 3 phases and the factors that impact movement through these phases and shapes.

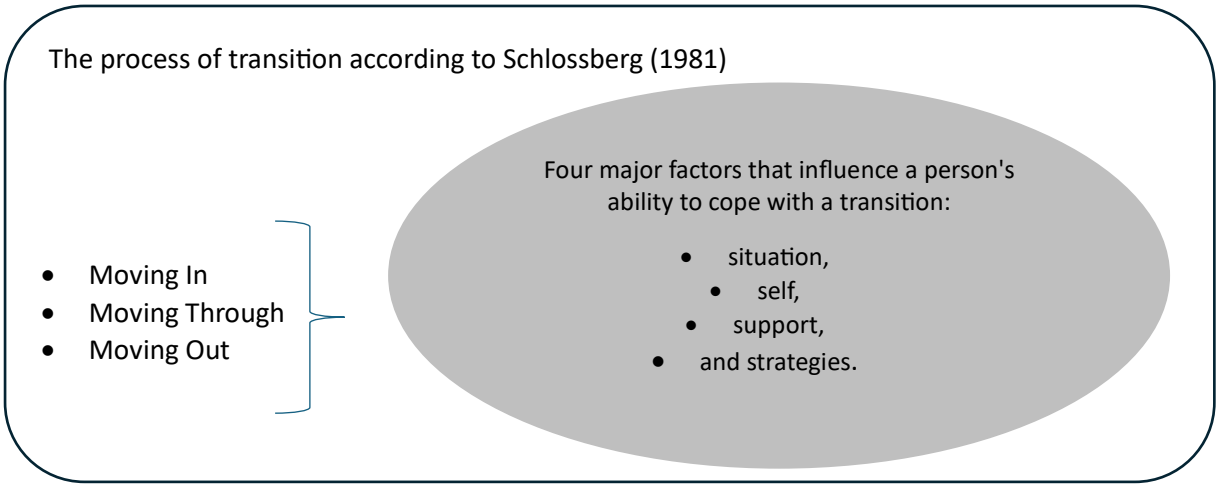

Figure 3.1 The process of transition according to Schlossberg (1981)

3.2.1 Relevance to TVET Engineering Students

The application of Schlossberg's theory is appropriate because TVET students experience numerous transitions throughout their educational journey (Killam & Degges-White, 2017). Adaptation to change is inherently complex; it varies based on the characteristics of the individual, the nature of the transition itself, and the pre- and post-transition environment (Schlossberg, 1981). As Anderson et al. (2012) emphasise, these transitions can be particularly challenging in educational settings where students must simultaneously navigate academic demands, social adjustments, and identity development.

3.2.2 Individual Characteristics and Intersectionality

Individuals experience life transitions differently due to variations in characteristics such as age, gender, ability, race, socioeconomic status, psychosocial competence, and previous life experiences (Schlossberg, 1981). Moreover, the transition experience in an engineering programme varies significantly by race, socioeconomic status, and other personal characteristics.

In more recent literature on intersectionality, the overlapping characteristics of an individual's identity must be considered when examining how individual characteristics affect transitions (Josselson & Harway, 2012; Pawley et al., 2016). Crenshaw's (1989) foundational work on intersectionality, which was not cited in the original text, introduced this concept to highlight how multiple social categories combine to create unique experiences of discrimination or privilege. Intersectionality emphasises that overlapping categories such as race, class, gender, and sexuality can form a system of oppression that cannot be fully understood by examining only one of these categories in isolation (Stitt & Happel-Parkins, 2019).

For example, African women are likely to experience racism, sexism, and prejudice resulting from the intersectionality of race and gender (Stitt & Happel-Parkins, 2019). Research by Makhubela and Ntswane (2022) found that Black South African women in TVET engineering programmes faced unique barriers stemming from the intersection of their gender, race, and often rural backgrounds. Similarly, a Woman of Color may experience an engineering programme differently than a White woman for many reasons, including their more disproportionate underrepresentation in the engineering discipline and experiences with racism (Blosser, 2020; Jackson et al., 2013; Ong et al., 2020; Stitt & Happel-Parkins, 2019).

Women of Colour report feelings of isolation, struggle with hypervisibility and stereotype threat, sexual harassment, and exposure to microaggressions incidents of indirect, subtle, or unintentional discrimination against members of a marginalised group (Blosser, 2020; Ong et al., 2020). Recent studies by Mkhize and Ramjee (2023) document similar experiences among female engineering students at South African TVET colleges, where intersecting identities of race, gender, and socioeconomic status create unique challenges that require specific support interventions.

3.2.3 Contextual Factors in Transitions

Characteristics of transitions also vary at different times and in different contexts (Schlossberg, 1981). As a result, the same individuals may react differently to transitions at different stages in their lives. Goodman et al. (2006) expand on this concept, noting that transitions occur within specific socio-cultural contexts that shape their meaning and impact.

The experience of transitioning through the first year of college varies based on differences in the students and the institutions. The experiences may also vary due to the influence of the students' pre-college environments and experiences. For example, the level of academic preparation in high school is frequently cited as a predictor of success in engineering programmes (Iskander et al., 2013). Research by Thesen (2020) with South African TVET students found that inadequate secondary school preparation in Mathematics and Physical Sciences created significant barriers for female students entering engineering programmes.

In addition, engineering camps and outreach programmes have a significant impact on female participants' self-efficacy in engineering (Schilling & Pinnell, 2019). The Young Women in Engineering programme initiated at several South African TVET colleges showed promising results in building confidence and technical skills before formal enrolment (Department of Higher Education and Training, 2022).

- **Understanding Transitions**

Schlossberg (1981) stated that "a transition can be said to occur if an event or non-event results in a change in assumptions about oneself and the world and requires a corresponding change in one's behaviour and relationships". Transitions alter roles, routines, assumptions, and relationships (Schlossberg, 1981).

Entry into a TVET college engineering discipline, which is the context of this study, is an example of an event that represents a significant life transition. Non-events are anticipated events that do not occur. For example, dropping out of an engineering programme from which one is expected to attain a degree can be considered a non-event (Meyer & Marx, 2014). Evans et al. (2010) elaborate that transitions often involve psychological processes of disengagement from old roles and engagement with new ones.

- **Perceptions of Transitions**

Perceptions of transitions may vary significantly (Schlossberg, 1981). Transitions can be perceived as a gain or a loss, and the outcome may have both positive and negative aspects (Schlossberg, 1981). For example, the transition to a TVET engineering programme would frequently be perceived as a gain because completion of the degree/diploma is prestigious and can lead to earning a competitive wage (PCAST, 2012).

Perceptions may also vary by the source, timing, onset, and duration of a transition. A transition that causes one student severe stress may cause only minor stress to another (Schlossberg, 1981). Consequently, some students may have difficulty coping with the role of first year engineering students, while other students may easily transition to the role. Mlambo and Mabokela (2023) found that female engineering students at South African TVET colleges often experienced the transition differently based on factors such as family support, financial resources, and prior exposure to technical fields.

3.2.4 Impact of Transitions on Roles, Routines, Assumptions, and Relationships

Schlossberg (1981) asserted that transitions alter roles, routines, assumptions, and relationships. Entry into the first year of an engineering programme at a TVET college exemplifies how a transition transforms these aspects of students' lives.

- **Roles**

The transition requires students to assume the new role of TVET engineering students. In this role, students must negotiate the differences between their prior roles (i.e., high school student) and competing roles (i.e., employee, caregiver) with the new role of TVET student. This negotiation can be particularly challenging for female students who often balance significant family responsibilities with their academic pursuits (Akala & Divala, 2022).

- **Routines**

Students must also adjust routines, learn how to manage time, and balance the academic demands of TVET college with competing demands (Meyer & Marx, 2014). Recent research by Ntombela (2021) found that female engineering students at South African TVET colleges often struggled with lengthy commutes, family responsibilities, and inflexible laboratory schedules that complicated their daily routines.

- **Assumptions**

Students come to TVET colleges with preconceived assumptions about TVET colleges and the engineering programme. The academic demands of an engineering programme often challenge students' assumptions about their own abilities and competence (Meyer & Marx, 2014). Students frequently enter engineering programmes at a TVET college with a high level of self-efficacy (Baker et al., 2015). However, they are often overconfident and unrealistic about their academic abilities and may not have the skills needed for success in engineering coursework.

As a result, self-efficacy often declines for TVET college students transitioning into the first year of an engineering programme (Baker et al., 2015). Mpofu et al. (2024) documented similar patterns among female engineering students at South African TVET colleges, noting that initial confidence often gave way to self-doubt when confronted with challenging coursework and sometimes unwelcoming classroom environments.

- **Relationships**

Finally, the transition to college requires students to alter relationships. For example, students need to form relationships with faculty and peers to persist in college (Tinto, 1987, 1994; Tinto, 2017). Often, this alters existing relationships with family and friends, particularly when the increasing amount of time spent on studies diminishes the time spent maintaining prior relationships.

People who are undergoing transitions often feel marginalised and that they do not matter (Killam & Degges-White, 2017). Faculty and employees at colleges can help students through actions and words that assure them that they matter (Killam & Degges-White, 2017; Schlossberg, 1989). Schlossberg's concept of "mattering" has become increasingly important

in understanding student persistence and success, particularly for underrepresented students in STEM fields (Tovar et al., 2009).

3.2.5 The Four S's: Situation, Self, Support, and Strategies

Schlossberg (1981) posited that the following factors impact the ability to cope with transitions: situation, self, support, and strategies (Anderson et al., 2012; Schlossberg, 2011). This framework, often called the "4 S's," provides a systematic approach to understanding how students navigate transitions.

- **Situation**

Situation refers to other life circumstances and stressors at the time of the transition. TVET college personnel ought to be able to assess the student's situation to help them navigate the transition (Killam & Degges-White, 2017). Factors to consider when helping students include the following: Is the transition an event or non-event? Is it anticipated or not? What are the timing and duration of the transition? Has the student experienced similar transitions before? What are the concurrent stressors?

Recent research by Motsabi et al. (2023) found that female engineering students at South African TVET colleges often faced situational challenges, including financial constraints, transportation difficulties, and family responsibilities that complicated their transition experience.

- **Self**

Self refers to an individual's inner strength and coping ability. Understanding "self" is important because college personnel need to understand students' experiences from the students' perspectives (Killam & Degges-White, 2017). Factors to consider include student demographics, identity, and psychological resources such as resilience and self-efficacy.

Studies by Moletsane (2022) found that personal characteristics such as resilience, determination, and self-advocacy were critical factors in the success of female engineering students at South African TVET colleges. Programmes that deliberately cultivated these attributes showed higher retention rates among female students.

- **Support**

Support implies the people and resources available to facilitate the transition. A strong support system is effective in helping students navigate transitions (Killam & Degges-White, 2017). Examples of support include co-curricular involvement, positive interactions with faculty and peers, relationships with family and friends, and other campus resources.

Jenkins and Walton (2023) examined support systems for female engineering students at South African TVET colleges and found that peer mentoring, women's engineering clubs, and faculty mentorship were particularly effective interventions. They also noted that financial support and childcare assistance addressed critical barriers for many students.

- **Strategies**

Strategies are tactics used to change or reframe a situation and represent the coping resources that help students navigate a transition (Killam & Degges-White, 2017). College employees can help students identify their coping resources and decide among the following options: change the situation, change the meaning of the situation, control and manage the situation, or deliberately do nothing about it (Killam & Degges-White, 2017).

Research by Baloyi and Makhanya (2021) found that successful female engineering students at South African TVET colleges employed specific strategies, including forming study groups, developing relationships with supportive faculty, advocating for themselves in group projects, and creating strict time management systems.

3.2.6 Application to Female Engineering Students

According to Killam and Degges-White (2017), Schlossberg's (1981) transition theory has rarely been applied to the topic of female students' experience and participation in engineering programmes but has been widely used by student development professionals to help students navigate transitions. Therefore, this study advances research on experience and participation in the engineering pipeline by applying Schlossberg's (1981) theory of transition.

It is important to understand how registered female students experience the transition into engineering disciplines at TVET colleges. Magubane (2023) argues that applying Schlossberg's framework to female engineering students in South African TVET colleges reveals unique challenges that require targeted interventions across all four dimensions of the model.

3.2.7 The Way Forward

Recent research by the Department of Higher Education and Training (2023) indicates that TVET colleges that implement comprehensive transition support programmes based on theoretical models like Schlossberg's show significantly higher retention and completion rates for female engineering students. These programmes typically include:

- Pre-enrolment outreach and preparation
- Comprehensive orientation addressing academic, social, and emotional aspects of transition
- Ongoing mentorship from female industry professionals
- Peer support networks
- Faculty development focused on inclusive teaching practices
- Regular assessment of student needs and program effectiveness

By understanding and addressing the complex transition experiences of female engineering students through Schlossberg's framework, TVET colleges can create more supportive and inclusive environments that foster success for all students.

3.3 Tinto's (1987) theory of student departure

Tinto's Theory of Student Departure provides the second theoretical prong for this study. Tinto's theory (1987) is the leading model in student retention literature; it focuses on student and institutional attributes that influence a student's decision to persist and complete college or drop out (Long, 2012; Mayhew et al., 2016; Snyder & Cudney, 2017). Tinto's (1987) theory explains student retention in terms of interactions and congruence between individual and institutional factors (Long, 2012).

Students enter college with different characteristics, including differences in socioeconomic status, family support, pre-college educational experiences, educational goals, and cultural and social values (Long, 2012; Tinto, 1987, 1994, 1997). Of these characteristics, the attributes of intention and commitment have a particularly strong influence on student experience, retention, and success (Snyder & Cudney, 2017; Tinto, 1994). Strong and clear career intentions are motivating forces that increase the likelihood of college persistence (Tinto, 1994). Tinto (1994) stated that the influence of career intentions on persistence is even more evident for occupations, including engineering. Student commitment to career goals and commitment to

the institution are predictors of persistence (Tinto, 1994). Student commitment to career goals is made evident through a willingness to work towards completing those goals. Moreover, commitment to career goals is influenced by academic ability (Tinto, 1994; White et al., 2018). Students with high goal commitment and high academic ability are most likely to persist. In contrast, students with low goal commitment and academic ability are most likely to drop out of college.

3.3.1 Individual Factors: Social Support and Self-Efficacy

Among the individual factors that Tinto identifies, social support from family and friends has been shown to significantly promote student persistence (Dorrance Hall et al., 2020). According to Dorrance Hall et al. (2020), students who perceive support, particularly from family members, are more likely to feel confident in their ability to adjust to college because they know they have people who will be available to provide support when needed and who believe in them. In alignment with Tinto's (1987) theory, social support in the form of parent and high school mentors served as a motivation to study engineering and correlated to persistence (Eris et al., 2010). Parents who support children by emphasising the importance and value of STEM skills may influence the self-efficacy and career development of girls and young women in STEM (Nugent et al., 2015; Scott & Mallinckrodt, 2005).

Bandura's (1997) self-efficacy theory complements Tinto's focus on goal commitment by asserting that people with high self-efficacy expectancy, the belief that they can achieve a goal, are generally more successful than those with low self-efficacy. This theory is frequently cited in the STEM retention literature. The research shows that high levels of academic self-efficacy and academic preparation, particularly in Mathematics and Science, have been correlated to persistence (Baker et al., 2015; Eris et al., 2010; Lent et al., 2016; Marra et al., 2012; Meyer & Marx, 2014; Navarro et al., 2014). In addition, student self-efficacy influenced engineering career goals and predicted persistence (Cadaret et al., 2017). However, women reported lower self-efficacy beliefs in STEM studies and low self-efficacy with respect to technical skills (Cadaret et al., 2017; Li et al., 2009), which may contribute to higher attrition rates among female engineering students.

3.3.2 Institutional Factors and Integration

Institutional factors, in combination with individual factors, contribute to a student's decision to persist or drop out (Snyder & Cudney, 2017; Tinto, 1987). Institutions and academic

programmes within those institutions have unique characteristics, which may vary in terms of fit for the students (Snyder & Cudney, 2017). A strong match between the student and institutional characteristics facilitates academic and social integration, but a mismatch may lead to conflict between the student and the decision to drop out (Long, 2012).

Experiences that may hinder student integration are adjustment, difficulty, incongruence, and isolation (Andreatta, 2008; Snyder & Cudney, 2017; Tinto, 1987). Adjustment means becoming comfortable and familiar with the new environment, including the academic demands of college and the engineering programme. Difficulty is experienced when a student is unable to meet academic standards; this is often the case with the rigorous "weed out" curriculum of engineering (Snyder & Cudney, 2017). Incongruence occurs when there is a mismatch between the needs and interests of the student and the characteristics of the institution. Finally, isolation is experienced when students fail to develop relationships with faculty and peers; this inhibits social integration (Tinto, 2012).

It is important to note that faculty and student relationships have a significant impact on student persistence (Snyder & Cudney, 2017; Tinto, 1987). Students may decide to drop out if the conflicts, which include adjustment, difficulty, incongruence, and isolation, remain unresolved. For example, the underrepresentation of females in engineering programmes, including the underrepresentation of females, particularly Females of Colour, in the engineering faculty, can lead to feelings of isolation, which increases females' risk of attrition (Arthur & Guy, 2020; Main et al., 2020).

According to Tinto (1987), students are integrated to varying degrees into academic and social systems at college and are more likely to persist when they experience increased academic and social integration. In addition, academic and social integration cannot be considered independently; they overlap and influence each other (Tinto, 1987). Academic difficulties, problems with integrating socially and academically into the culture of the college, and a low level of commitment to educational and career goals and the college are the primary reasons for student departure. Attrition in an engineering programme includes students who decide to switch majors or drop out altogether (Snyder & Cudney, 2017).

3.3.3 Critique and Extensions of Tinto's Framework

Tinto's (1987) theory helps to explain the experience and participation of females from engineering programmes at TVET colleges. However, a challenge is that the model is typically

used for quantitative studies of attrition at university level (Lee & Matusovich, 2016). In addition, the theory has been critiqued for inadequately addressing cultural differences and for alluding that assimilation leads to integration and retention (Lee & Matusovich, 2016).

This critique connects to reproduction theory, which offers another important lens for understanding student experiences. Reproduction theory asserts that social and cultural relations are translated as educational practices within educational systems. Therefore, this theory stresses the importance of understanding race, class, gender, and other social dynamics that re-emerge as patterns in educational practices (Bourdieu & Passeron, 1977). For example, Bourdieu and Passeron's (1977) concept of social capital included relationships and social networks, while cultural capital included a person's assets, including attitudes, knowledge, skills, and behaviour, that promote upward mobility and make the educational system feel familiar and comfortable. Students with abundant social and cultural capital tend to persist in college (Dika & Martin, 2018). This framework helps explain why underrepresented students, including women in engineering, may face additional barriers to integration and persistence.

3.3.4 Gender-Specific Challenges in Engineering Education

There is a greater likelihood of difficulties with academic and social integration for women in engineering programmes. Social integration, in particular, can be hindered by female students' experiences with bias and sexism; this problem is compounded because females typically prefer learning in a highly collaborative and social environment (Marra et al., 2012; Ro & Knight, 2016). Females are an underrepresented group who may experience bias, sexism, and a "chilly climate" in which females are not well accepted (Jones et al., 2013; Pawley et al., 2016; Smith & Gayles, 2018). Sexism is a type of bias, prejudice, and discrimination based on sex; it may be further "defined as the systematic and unearned advantages given to men that are rooted in privilege and power" (Smith & Gayles, 2018, p. 3).

Females may also experience stereotype threat, which is anxiety about confirming a negative stereotype of females' performance in engineering (Jones et al., 2013; Pawley et al., 2016). Likewise, females may experience conflict with the predominant culture and values that they encounter in engineering programmes, which have rigorous academic demands and a culture of competition that may create gender-related tensions for females (Hicks & Wood, 2016; Jackson, 2013; Reyes, 2011; Wilson & Kittleson, 2013).

3.3.5 Seminal Studies on STEM Retention

Following the tradition of Tinto's (1987) theory of student departure and Bourdieu and Passeron's (1977) reproduction theory, two seminal works include Seymour and Hewitt's (1997) qualitative study of students who leave the sciences and Adelman's (1998) study of women and men in engineering.

Seymour and Hewitt (1997) identified the following reasons for attrition from science and engineering programmes: student boredom or disillusionment with the curriculum and loss of academic self-confidence due to the competitive environment. Based on a 3-year, seven-campus study, Seymour and Hewitt (1997) and later Seymour et al. (2019) expanded and applied Tinto's (1987) theory and other persistence frameworks to STEM education to identify processes that accounted for student decisions to leave STEM majors. They categorised these factors as:

- "Push" factors - problems in students' precollege and college experiences that made it difficult for them to persist with their original choices of majors and career aspirations
- "Pull" factors - perceived attractions or advantages that drew students to alternative majors and career possibilities - often while they struggled with problems in their original STEM majors and
- Pragmatic or instrumental considerations that made students' original choices seem less feasible or promising than the alternatives they were considering.

In contrast to those who switched out of STEM majors, "per-sisters" had a higher entry level of preparation for Mathematics and Science courses, identified and sought help and support, developed strategies to cope with the design, pedagogy, and grading practices of STEM courses, and encountered fewer difficulties (Hunter, 2019). According to Seymour et al. (2019), the four factors contributing most to switching were two "push" factors (the effects of poor teaching by STEM instructors and overwhelm created by the heavy pace and load of course demands), and two "pull" factors (consequential loss of incoming interest in the STEM major while assessing a non-STEM alternative as offering more interest and a better education). A significant discovery included the loss of high-performing students, especially women.

Adelman (1998) studied the behaviour of men and women studying engineering and described the path that engineering students followed from entry into the programme to completion of a degree. Adelman (1998) found gender differences between students who left and those who persisted in the engineering programme. A disproportionate number of students who left

engineering programmes were women and students of Colour (Snyder & Cudney, 2017). Adelman (1998) also found that an accelerated curriculum, including advanced preparation in secondary school Mathematics and successful performance in trigonometry, bolsters student likelihood of persistence in engineering. Moreover, the literature indicates that it is important to understand retention and attrition for first-year students because the first year of study is a critical gateway for students' success in STEM majors (Marra et al., 2012).

3.3.6 Additional Contemporary Research on Female Persistence in Engineering

Recent studies have expanded on these foundational works. Blosser (2020) found that women who persisted in engineering often developed coping mechanisms and support networks to navigate the male-dominated environment. These included finding female mentors, joining women in engineering organisations, and developing strong peer support systems. Similarly, Wilkins-Yel et al. (2020) highlighted the importance of "persistence networks" that provide academic, emotional, and professional development support specifically for women in engineering.

Research by Dennehy and Dasgupta (2017) demonstrated that same-gender peer mentoring during the first year significantly increased women's belonging, confidence, motivation, and retention in engineering. Their longitudinal study showed that female mentors functioned as "social vaccines" who inoculated women against negative stereotypes and increased their identification with engineering.

Institutional initiatives that promote a collaborative rather than competitive learning environment have also shown positive impacts on female retention. Faulkner et al. (2019) found that redesigned introductory engineering courses that emphasised teamwork, real-world applications, and inclusive teaching practices significantly improved retention rates for women and other underrepresented groups.

3.3.7 Implications for Practice

The theoretical frameworks and empirical findings discussed above suggest several practical implications for engineering education:

- Early intervention programmes should target both academic preparation and psychological factors like self-efficacy, particularly for female students
- Faculty development programmes should address inclusive teaching practices and awareness of implicit bias
- Engineering programmes should create opportunities for meaningful faculty-student interactions, especially for underrepresented students.
- Institutions should promote peer support networks and mentoring programmes, particularly for women and minorities.
- Curriculum design should incorporate collaborative learning experiences and real-world applications that align with female students' learning preferences.
- Institutional policies should address systemic barriers and "chilly climate" issues that disproportionately affect women in engineering.

By integrating Tinto's framework with gender-specific considerations and implementing evidence-based practices, engineering programmes can create more inclusive environments that support the persistence and success of all students, including women who have historically been underrepresented.

3.4 Conclusion

This chapter explained the theoretical framework that was used to frame this research. The chapter further explained how it relates to Tinto’s theory of students’ departure. The next chapter of this study discusses the research methodology.

Chapter 4

Research methodology

4.1 Introduction

As mentioned previously, The purpose of this study was to explore and unveil female students' experiences in engineering disciplines at a technical and vocational education and training college.This chapter set out to highlight the research methodology embraced in this study. According to Flick (2015), research methodology elucidates the different stages of a study, from data generation to analysis. The following research questions were addressed by this study: What are female students' experiences in engineering disciplines at a Technical Vocational Education and Training College? The -sub-research questions were as follows: *1. What are registered female students' experiences in the various engineering disciplines at the TVET college? 2. How do these experiences relate to their participation and performance in these engineering disciplines? 3. Why do registered female students have these experiences in the engineering disciplines at TVET colleges?* The chapter considers the following aspects of methodology: paradigm, researcher positionality, location of the study, data generation plan, research instruments, research rigour, and ethical considerations, and ends with a summary of the chapter.

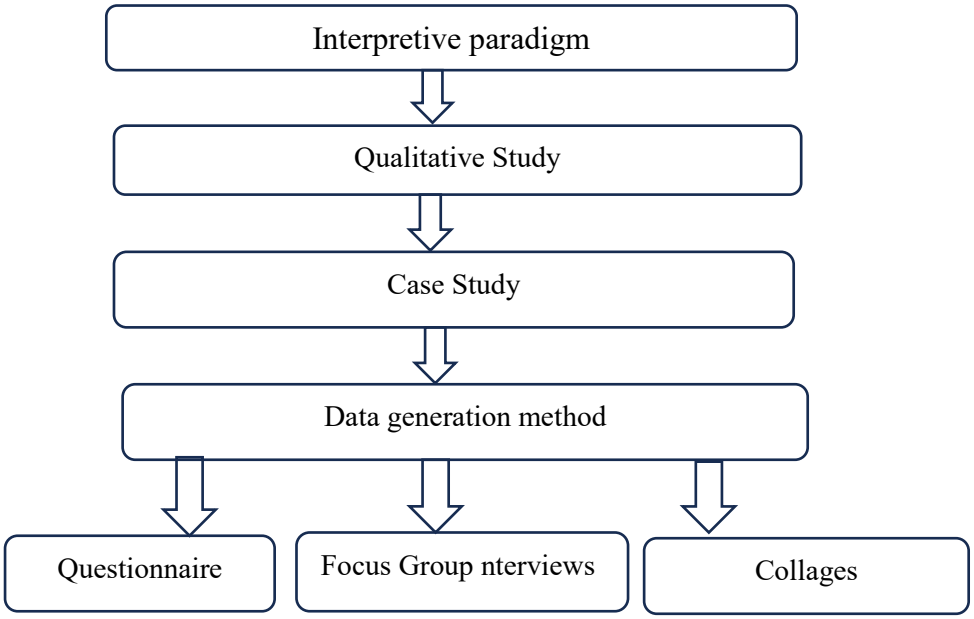

Figure 4.1 A diagrammatic illustration of the structure of the research methodology chapter.

4.2 Context of the study

In this study, the sample was drawn from female students registered at Campuses A and B of the TVET college, enrolled in engineering disciplines. This sampling approach was particularly relevant given the historically low participation rates of females in engineering education. While female enrolment in higher education overall has increased significantly in recent decades, engineering programmes continue to show gender disparities, with females representing a minority of students in most engineering disciplines at TVET colleges.

The theoretical foundation for this study was Schlossberg's (1981) transition theory, which focuses on moving in, moving through, and moving out of a life transition. This framework provides an appropriate lens for examining the experiences of female engineering students as they navigate traditionally male-dominated educational environments. The transition identified in this study was the journey of registered female students in engineering programmes at TVET colleges.

In this study, "moving in" referred to the initial enrolment and orientation of female students in engineering programmes at TVET colleges. This phase is characterised by assessment, planning, and learning about new roles, relationships, and routines (Killam et al., 2017). For female engineering students, this phase includes adapting to technical curricula and establishing their place in predominantly male classrooms.

"Moving through" represents the middle stage of transition, which is characterised by increased learning and adjustment to new roles, relationships, and routines (Killam et al., 2017; Anderson et al., 2011). At this stage, students are better able to balance academic demands with competing responsibilities, including work and relationships with family and friends (Killam et al., 2017). For female engineering students, this stage often involves developing coping strategies for gender-related challenges while building technical competence.

"Moving out" is the final stage of transition and paves the way for the next life transition when female students persist in studying engineering. This stage may involve preparation for advanced studies, industry placement, or graduation. Schlossberg's focus on a person's adaptation to change (Schlossberg, 1981) aligns directly with this study's examination of how female students navigate and persist in engineering education environments.

4.3 Research paradigm

The key to establishing a clear direction for the method of enquiry is choosing an appropriate paradigm. The paradigm guides the thought patterns and actions throughout the study. A paradigm serves as a frame of reference used to organise observations and reasoning (Maxwell, 2016), functioning as a lens through which to view phenomena and make decisions regarding framing, literature, methods, and research design (Cohen et al., 2018).

As this study sought to explore female students' experiences in engineering disciplines at a Technical Vocational Education and Training (TVET) college, I embraced the interpretive paradigm. The interpretive paradigm was particularly suited for this research as it aimed to describe and understand how people make sense of their context and actions (Bertram, 2014, p.3). Within this paradigm, researchers seek to understand the subjective world of human experience and derive meaning from shared experiences (Cohen et al., 2017). This approach allowed me to describe and make sense of social phenomena, specifically the opinions and experiences of female engineering students, from the participants' own perspectives.

All research paradigms encompass four philosophical assumptions: ontology, epistemology, axiology, and methodology (Creswell, 2013; Mertens, 2010). The interpretive paradigm is characterised by its focus on the individual, small-scale research, acknowledgement of subjectivity, qualitative approaches, recognition of multiple directions of causality, and emphasis on understanding actions and reasons rather than simple cause-and-effect relationships (Cohen et al., 2018).

From an ontological perspective, the interpretive paradigm acknowledges the existence of multiple realities. This was essential for my study, as I sought to understand the reality of female students in engineering disciplines at a TVET college, recognising that this reality could only be understood through their perspectives. As Cohen et al. (2018) state, the researcher's role in the interpretive paradigm is "to understand, explain, and demystify social reality through the eyes of the participants". Consequently, I used the participants' descriptions of their experiences as the primary data for this study.

Epistemologically, interpretivism values the subjective meaning of social phenomena (Cohen et al., 2018). Epistemology deals with researching and enquiring into the nature of reality and knowledge creation. This study generated credible knowledge through multiple qualitative methods: focus group interviews, open-ended questionnaires, and collages. This triangulation of data sources enhanced the depth and credibility of the findings.

The axiological dimension of research is concerned with values and ethics during data generation. In adherence to sound axiological principles, I ensured that participants were aware of voluntary participation and their right to withdraw from the study without repercussions. Furthermore, I engaged in straightforward, honest data generation, member checking, and explicit details on data analysis and shared my findings with my supervisor to maintain integrity throughout the research process.

My choice of the interpretive paradigm was influenced by three key factors: the theoretical framework of the study, assumptions about the nature of reality, and ethical value systems. This paradigm provided the most appropriate foundation for the qualitative approach employed in this research, allowing for a rich, contextual understanding of female students' experiences in engineering disciplines at TVET colleges."

4.4 Qualitative research approach

The selection of an appropriate research approach was guided by the ontological position of the interpretive paradigm, which served as the foundation for exploring female students' experiences in engineering disciplines at Technical Vocational Education and Training (TVET) colleges. Ontology concerns how we interpret our physical world and ourselves as human beings (Yom, 2015), and this study informed how I approached understanding the lived realities of female engineering students.

A qualitative approach was selected because it embraces the notion of multiple social realities, aligning perfectly with the interpretive paradigm's ontological assumptions. Qualitative research offers suitable methodologies when seeking an in-depth understanding of real-life phenomena, particularly human subjective experiences, living contexts, social behaviours, personal perspectives, and views on social issues (Flick, 2021). This approach allowed me to capture the richness and complexity of female students' experiences in male-dominated engineering programmes.

The research problem focused specifically on understanding how female students navigate their educational journey in engineering disciplines at TVET Colleges, making a qualitative approach particularly relevant (Creswell, 2013). According to Patton (2014) and Schwandt (2014), qualitative research aims to comprehend "the meaning of human action" by documenting and interpreting significance rather than simply measuring outcomes. Qualitative

enquiry addresses the "why" questions (Creswell, 2013), allowing for a deeper exploration of motivations, challenges, and experiences.

Guided by Schlossberg's transition theory, this study explored female students' experiences throughout their educational journey in engineering disciplines at TVET colleges. The qualitative approach enabled me to examine three critical transition phases: how female students "move into" the first year/trimester of study (initial adjustment), how they "move through" the programme (ongoing navigation of challenges and opportunities), and how they "move out" at the end of their qualification (preparation for career entry or further education). This framework provided a structured yet flexible lens through which to understand the complete arc of their educational experience while honouring the complexity of their individual stories.

4.5 Case study research design

Yin (2017) defined case study research as an empirical enquiry that investigates a contemporary phenomenon within its real-life context in which multiple sources of evidence are used. This approach focuses on a single entity, which can be a person, group, organisation, event, action, or situation. According to Creswell (2014), a qualitative case study explores a bounded case through in-depth data collection over time, involving various sources of information, each with its sampling, data collection, and analysis strategies.

In this study, I employed a case study design to explore female students' experiences in engineering disciplines at a Technical and Vocational Education and Training (TVET) college. This approach was particularly appropriate because it enabled me to gather in-depth information from participants using multiple research instruments. Case studies are valuable for preliminary and exploratory investigations as they facilitate thorough data collection, summarisation, presentation, and analysis for any required clarification (Mitchell, 2001).

Case studies can be classified into three types based on their outcomes: exploratory, descriptive, and explanatory (Yin, 1994). For this research, I specifically utilised an exploratory case study approach, which is well-suited for gaining fresh insights and clarifying understanding of complex processes. Through this approach, I selected 21 female engineering students to explore and unveil their experiences as they navigate their educational journey. The

exploratory technique provided new and thorough knowledge about this phenomenon, which can inform policy and serve as a foundation for additional research.

The research design incorporated specific details of how the study was conducted, including data collection methods, instruments used, and analytical approaches (Cohen et al., 2002). Using Yin's (2016) systematic framework, this case study explored the contemporary phenomenon of female students in engineering within the real-life context of a TVET college. Particularly, I focused on capturing the reality of these students' lived experiences as they 'moved in, moved through, and moved out' of their engineering programmes, aligning with Schlossberg's transition theory.

This case study design determined the sampling parameters and shaped the multiple data collection methods employed, including questionnaires, semi-structured interviews, and focus groups. These instruments were selected to provide a detailed account of how gender factors influence career paths in engineering. The bounded nature of the case study allowed for in-depth exploration within a specific institutional context while maintaining methodological rigour.

4.6 Sampling and sampling methods

Yin (2016) defined sampling as a selection of participants to address research purposes. In agreement with this definition, Gentles et al. (2015) described sampling in qualitative research as gathering information from a selected group of participants to gauge answers in response to the research questions posed. Similarly, Moser (2018) asserted that sampling involves making proper decisions about which people, settings, events, or behaviours to be included in a research study for data collection, essentially determining the population and context to be employed in a study. There are various sampling methods used in research, with the case study design informing the choice of participants. For this study, purposive sampling was the preferred method.

Purposive sampling, according to Maniram and Maistry (2018), as well as Etikan et al. (2016), is a deliberate act of choosing participants based on the attributes they possess. It is not done randomly; the researcher finds participants who can provide relevant information needed for the study based on their experiences or knowledge. For this research, participants must be female engineering students from Western TVET College, specifically from Krugersdorp West

and Randfontein Campuses. The location of the study, namely Western TVET College, was purposively selected, as I am employed at the college and had easy access to the participants.

Participants who met the above-mentioned criteria were invited to participate in this study. For Campus A, which offers three streams of engineering, 3 students per stream were selected (3×3=9 students). For Campus B, which offers 4 streams of engineering, 3 students per stream were selected (4×3=12 students). In total, 21 female engineering students participated in this study."

4.7 Researcher positionality

I declared up front that I am an employee of a TVET College. In my position, I am not working directly with students. Therefore, to address issues of power relations, informed consent was sought from all participants. They were informed that participation was voluntary, and they could+ withdraw from the study at any time without repercussions**.** All data and transcripts were taken to them for member checking.

4.8 Location of the study

The selected TVET college is one of 50 public TVET colleges that form part of the Department of Higher Education and Training. It consists of four campuses and one learning satellite, Campuses A to D. This study was conducted at Campuses A, and B of the selected TVET college as it is easily accessible and close to where the researcher resides.

The courses offered at Campus A are Report 191 (Nated) N1 to N6 programmes, which are Motor Mechanics, Boiler Making, Electrical Engineering, and NCV (National Curriculum Vocational) Electrical Infrastructure Construction L2 to L4. In comparison, Campus B offers, among others, Engineering Studies R191 Nated N1 to N6 with the following disciplines: Fitting, Platers, Motor and Diesel Mechanics, and NCV Engineering Related Design L2 to L4.

The selected TVET College is in West Rand District Municipality (WRDM). The WRDM, a Category C municipality in the western part of the province, is made up of the 3 local governments. The area is well-known for housing the Cradle of Humanity World Heritage Site and being close to OR Tambo and Lanseria International Airport.

The selected TVET College has 4 campuses and 1 learning satellite. The College SP 2022 - 2024

Radius from the Central/Head Office

- Campus A 3 Kilometres
- Campus B 9 Kilometres
- Campus C 9 Kilometres
- Campus C 38 Kilometres
- The learning site 20 Kilometres

In the strategic plan for 2020 to 2024, Campus A projects to enrol around 700 Report 191 (NATED) students and 400 NCV L2 to L4 students yearly. In comparison, Campus B plans to register around 2000 R191, of which Nated students and 500 NCV L2 to L4. Campus A has 22 Engineering Studies lecturers, and Campus B has 26 Engineering Studies lecturers.

4.9 Data generation plan

Lewis (2015) defined data generation as an exercise of gathering a set of interrelated information to answer the research questions posed. Thus, the importance of data generation cannot be overemphasised as it is meant to contribute to a better comprehension of a framework (Bernard, 2017). It is therefore important that decisions on how the data will be obtained and from whom the data will be obtained, be reasonably and carefully done, as no amount of analysis complements an inaccurate collection of data (Etikan et al., 2016). This means that for the researcher to get the right information concerning a study, the right participants/data sources and instruments must be selected. In this study, questionnaires, focus group interviews and collages were used to generate data, as depicted in Table 1 below:

Table 4.1 Data generation plan

Research question	Data source	Instrument	analysis
1. What are registered female students' experiences in the various engineering disciplines at the TVET college?	Engineering female students	Open-ended questionnaire Focus group Interviews	Content analysis
2. How do these experiences relate to their participation and performance in these engineering disciplines?	Engineering female students	Collages making Post-collage-making focus group interviews	Content analysis
3. Why do registered female students have these experiences in the engineering disciplines at TVET colleges?	Engineering female students	Open-ended questionnaire Focus group interviews	Content analysis

Data was generated in 3 phases in response to each research question, as depicted above. The research instruments are discussed next.

4.10 Research instruments

Three complementary instruments were employed to generate data for this study: open-ended questionnaires, focus group interviews, and collages. As Pitsoe and Nieuwenhuis (2001) assert, these methods share a complementary relationship that enhances the trustworthiness and crystallisation of findings, providing "a complex and deeper understanding of the phenomenon." This multi-method approach facilitated data triangulation, offering different perspectives on the critical research questions and yielding a more comprehensive understanding of female engineering students' experiences.

4.10.1 Open-ended Questionnaire

The open-ended questionnaire served as the initial data collection instrument, designed to allow participants to express themselves without constraints. According to Cohen et al. (2022), open-ended questions enable respondents to answer freely, making them particularly suitable for exploring complex issues that require more than simple responses. This approach offers several

advantages: it is economical in terms of time and money, provides identical questions to all participants (unlike interviews where questions might vary), and allows participants adequate time to contemplate their responses.

The rationale for beginning with the open-ended questionnaire was twofold. Firstly, it provided participants with the privacy to answer questions in their own words, reducing the possibility of researcher misinterpretation. Secondly, the responses gathered could be further explored during subsequent focus group interviews.

To ensure quality and relevance, the questionnaire was piloted with female engineering students from another TVET college to check for clarity and eliminate ambiguities or difficult wording. Cohen et al. (2022) emphasise that such pilot studies enhance reliability, validity, and practicability. The final questionnaire contained eleven questions specifically designed to explore female students' experiences "moving in" to the Engineering Programme at a TVET college. The questionnaires were physically distributed to students across both campus locations.

4.10.2 Focus Group Interviews

The second instrument employed was focus group interviews, which Cohen et al. (2022) describe as an unstructured discussion between the researcher and participants that serves as a valuable source of qualitative data. Creswell and Creswell (2017) note that focus groups typically comprise four to six people with similar experiences or perspectives. As Yin (2016) emphasises, these groups are "focused" because they assemble people with similar experiences or views.

The purpose of these interviews was not to reach a consensus but rather to gather diverse perspectives on how female students are supported in engineering disciplines and to identify factors that enable or constrain their participation. Two focus group interviews were conducted and audio recorded. Patton (2014) observes that focus group dynamics often encourage deeper participation as participants listen to and build upon each other's contributions.

The interviews were conducted in comfortable, neutral environments such as campus offices or resource centres, with some students opting for Zoom interviews. Following Van Manen's (2016) approach, a conversational tone was maintained throughout to establish trust and elicit richer narratives about lived experiences. The questions were structured to reflect Schlossberg's

(1981) transition theory, exploring the "moving in," "moving through," and "moving out" stages of the college experience, along with the four S's (situation, self, supports, and strategies) that help individuals cope with transitions.

4.10.3 Collages

The third instrument utilised was collage-making, an artistic process gaining recognition as a valid research methodology in education (Gerstenblatt, 2013; Roberts & Woods, 2018). Kara (2015) identifies arts-based and visual methods as "effective ways to address complex questions in social science." These techniques allow participants to process their experiences thoughtfully and at their own pace (Loads, 2009; Roberts & Woods, 2018).

Collage-making serves multiple purposes in research: it aids in concept conceptualisation, can "shock and surprise" (Burge, 2016), and provides an alternative method for expressing complex experiences and deep feelings in creative, non-linear ways. The physical involvement in creating collages gives participants agency (Roberts & Woods, 2018), accessing deeper levels of consciousness and allowing exploration of experiences from different angles than verbal interviews alone.

Participants were provided with materials and guidelines on how to capture their experiences through collage. They worked at their own pace, reflecting and rearranging elements as their ideas evolved. While the process could evoke both positive and negative memories, it offered cathartic opportunities for participants to have their feelings acknowledged (Mannay et al., 2017). As part of the ethical responsibility to participants, information about available support resources, such as the college's student support services, was provided.

The post-collage development interviews further demonstrated the effectiveness of this approach in giving voice to underrepresented groups, particularly women in engineering (Patton, 2014). The collage discussions were guided by Vandermause and Fleming's (2011) model for interpretative interview questions, designed to spark meaningful conversation about lived experiences.

Overally, this triangulated approach to data collection, combining open-ended questionnaires, focus group interviews, and collages, aligns with both Tinto's (1987, 1997) model of student departure and Schlossberg's (1981) transition theory. Together, these instruments provided a

comprehensive framework for understanding the experiences of female engineering students as they moved in, through, and out of their TVET college programmes.

4.11 Data analysis

According to Merriam (2015), data analysis is the process of deriving meaning from datasets. This definition is complemented by Cohen et al. (2020), who describe it as "reviewing each unit of analysis and categorising it according to the predefined categories." In preparation for this analytical process, all audio recordings from interviews and lesson observations were transcribed verbatim.

The researcher employed qualitative data analysis, which Creswell and Poth (2018) characterise as a complex, iterative process rather than a linear one. As Miles et al. (2020) explain, qualitative analysis is inherently recursive, iterative, and progressive. This cyclical quality became evident throughout this study's analytical process. As the researcher analysed data from female engineering students' interviews, new trends and patterns continuously emerged, necessitating repeated returns to the data, making the process reiterative and progressive (Saldaña, 2021).

The analysis demonstrated recursively when, after examining the questionnaires, the researcher returned to participants' responses from open-ended questionnaires, focus group interviews, and post-collage-making interviews. This recursive approach allowed the researcher to identify convergence between these three data sources, creating what Patton (2015) refers to as the "triangulation of qualitative data sources" a critical strategy for enhancing the credibility and depth of qualitative findings.

The data generated in this study underwent content analysis, which Krippendorff (2018) defines as a research technique for making replicable and valid inferences from texts to the contexts of their use. Content analysis involves organising data into meaningful categories and themes (Elo & Kyngäs, 2008). In this study, coding was employed as the primary categorisation strategy. Coding, as described by Saldaña (2021), is the process of identifying themes or concepts within the data. The constructs of the transition framework were utilised as coding parameters to ensure theoretical alignment.

Following Strauss and Corbin's (1998) grounded theory approach, the researcher implemented a three-stage coding process:

- Open coding: The process of breaking down, examining, comparing, conceptualising, and characterising data. This initial stage involved identifying and labelling concepts within the raw data that appeared significant to the participants' experiences (Charmaz, 2014). The researcher examined transcripts line by line, identifying key phrases and concepts related to female engineering students' experiences.
- Axial coding: A set of procedures whereby data are reassembled in new ways after open coding by making connections between categories. This stage utilised a coding paradigm involving conditions, context, action or interactional strategies, and consequences (Corbin & Strauss, 2015). During this phase, the researcher identified relationships between the categories that emerged during open coding, examining how different aspects of female students' experiences connected to one another.
- Selective coding: The process of selecting the core category and systematically relating it to other categories, validating those relationships, and refining categories that need further development (Flick, 2018). In this final coding stage, the researcher identified central phenomena around which other categories could be integrated, creating a coherent analytical narrative about female engineering students' experiences.

These three types of coding were employed to examine the dynamic transactional relationship among the experiences of female engineering students as they moved in, lived through, and moved out of the Technical and Vocational Education and Training college. To map the transactional interplay within the data, the researcher traced trends and patterns that appeared across multiple data sources: focus group interviews, post-collage focused group interviews, and questionnaires.

The researcher noted consistencies in the collage-making presentations and identified codes that emerged inductively from the data. Following Patton's (2015) guidance, the researcher searched for codes that demonstrated "internal convergence and external divergence," ensuring that each code was internally consistent but distinct from others. This approach aligns with what Braun and Clarke (2021) describe as reflexive thematic analysis, which emphasises the active role of the researcher in identifying patterns and themes.

The analytical process involved rigorous, repetitive reading and coding of transcripts to develop key themes, a practice that Guest et al. (2012) identify as essential for robust qualitative analysis. As described by Flick (2018), transcripts were read "horizontally, which involves

grouping segments of text by theme." This horizontal reading allowed for thematic integration across different data sources and participants.

Through this process, major themes were condensed into sub-themes to facilitate more focused analysis. The researcher engaged with the data critically, establishing links within and across different data sources. This approach aligns with what Bazeley (2020) terms "integrated analysis," where different types of data are brought together to create a more comprehensive understanding of the phenomenon under study.

The interpretive process was guided by Creswell and Creswell's (2017) assertion that qualitative data analysis involves "making sense of text and image data." The researcher not only identified patterns but also interpreted their significance within the context of female students' experiences in engineering programmes. As Denzin and Lincoln (2018) suggest, qualitative analysis involves not just organising data but interpreting it in ways that illuminate the lived experiences of participants.

Through this comprehensive analytical approach, the researcher developed a nuanced understanding of female engineering students' experiences as they navigated through TVET college, capturing both common patterns and individual variations in their educational journeys (Tracy, 2020).

4.12 Ensuring rigour in the research

Rigour encompasses all methodological steps performed during research to guarantee accuracy and consistency. When rigour is inadequately established, a study's integrity becomes fundamentally compromised. As Krefting (1991) emphasises, the value of any research study lies in readers' ability to critically analyse it, regardless of the methodology employed. Therefore, research reports must provide sufficient detail for readers and other researchers to evaluate the study's quality and trustworthiness.

To establish scientific rigour in this study, multiple data collection techniques were implemented, including semi-structured interviews, focus group interviews, and collages. This approach aligns with Mays and Pope's (1995) assertion that rigour in qualitative research is primarily influenced by questions of validity and dependability. Additional measures employed included member checking and participant reflection on both data generation methods and

transcription processes. To ensure accuracy in representing participants' responses, all interview audio data was transcribed verbatim before theme generation began.

4.12.1 Establishing Dependability and Confirmability

Dependability, according to Patterson (2014), emphasises the researcher's due diligence in ensuring that study procedures are rational, traceable, and thoroughly documented. Complementarily, confirmability requires that all claims, conclusions, and interpretations be logically connected to the empirical evidence (Patton, 2014). In this study, several strategies were employed to strengthen both dependability and confirmability:

- Prolonged engagement with participants and immersion in the data
- Triangulation through multiple data sources, including focus groups, interview and collages
- Detailed protocol writing
- Systematic examination and deep consideration of the data
- Rigorous documentation throughout the writing process

Following Van Manen's (2016) recommendation for external audit in phenomenological research, member checking was conducted with the focus group. This process, as Creswell (2013) notes, enhanced the interpretation's richness and depth through new participant insights. Additionally, the writing process itself served as a record of the analytical journey, from process notes and reflections to the completed dissertation. The hermeneutic writing approach, with its reflective-interpretive nature, further compelled the researcher to establish logical connections between data and interpretation.

4.12.2 Ensuring Transferability

Transferability refers to the capacity to make generalisations across cases (Patterson, 2014). To enhance transferability, careful and repeated reading of the "text" was conducted, as outlined in the analysis section. Van Manen (2016) distinguishes between two types of experiential generalisations, existential generalisation and solitary generalisation, while noting that empirical generalisability cannot be applied to phenomenological studies. Nevertheless, the findings from a hermeneutic phenomenological study may prove valuable in diverse contexts.

Existential generalisation facilitates understanding of the universal or fundamental aspects of a particular phenomenon, while singular generalisation focuses on its individual or distinctive characteristics (Van Manen, 2016). Through purposeful criteria sampling, the researcher ensured that all participants had experienced the same phenomenon, enhancing the study's transferability potential (Creswell, 2013; Patton, 2014).

4.12.3 Validity and Reliability Considerations

Clark and Creswell (2008) note that qualitative research encompasses both internal and external validity and reliability. Validity fundamentally addresses how effectively an instrument asks the right questions. In this study, content validity was evaluated through two approaches:

Firstly, the researcher engaged in discussions with engineering department students, teachers, and management regarding the instrument's components. Their input helped determine the reliability of the study instruments. Secondly, content validity was assessed through piloting, where respondents' responses were compared against study objectives to verify that the questionnaire's phrasing and framing were clear and comprehensible.

Reliability, as Mohajan (2017) explains, determines whether similar results can be obtained using a comparable methodology. To enhance reliability, the researcher employed pre-approved and validated interview questions designed to measure their intended indicators.

4.12.4 Establishing Credibility

Creswell (2013) and Patton (2014) define validity as the extent to which research faithfully translates findings to reflect participants' intended meanings. Credibility fosters alignment between participants' understanding of the phenomenon and the researcher's representation of it. The focus group was instrumental in maintaining credibility, facilitating member verification and data triangulation by providing a secondary data source to confirm conclusions derived from interview and protocol document analysis (Creswell, 2013).

Additionally, insight cultivators served as an additional data source for triangulation. This was accomplished by comparing and connecting data collected from these insight cultivators with interpretations and conclusions from the focus group interviews. According to Patton (2014), credible qualitative research requires:

- Rigorous, thorough fieldwork producing high-quality data
- Systematic, diligent data analysis with attention to credibility concerns
- Readers' and users' philosophical convictions regarding the value of qualitative enquiry
- Inquirer credibility based on training, experience, track record, status, and self-presentation

To establish credibility throughout the data collection process, the researcher conducted an internal audit using these questions, adhered to the protocols described in the methodology, consulted the literature on focus group interview best practices, and maintained detailed notes during data collection.

For thematic analysis, the researcher followed van Manen's guidelines, which included reflective journaling, repeated listening to interview recordings, and multiple readings of transcripts to identify rich experiential material. The study's trustworthiness was further enhanced through thick, detailed descriptions, a robust theoretical framework, and connections to insight cultivators in the humanities and arts (Creswell, 2013; Van Manen, 2016).

Through this comprehensive approach to methodological integrity, the research establishes a foundation of trustworthiness that strengthens the validity of its findings and their potential contribution to the field.

4.13 Gaining access

The researcher works for Western TVET College therefore, she had access to the staff members' email accounts and in-person interactions with the participants. Permission to conduct this research was sought from the Western TVET College Deputy Principal: academic services, the campus managers, lecturers, and female engineering students. The selected TVET college senior management received an access request email from the researcher, and a letter of approval is attached. The researcher was in touch with the lecturers and female students, who had signed a consent form. All this process was done after receiving approval to carry out the study and setting up a time for the collage-making and presentation, focused group interviews, and delivery of the questionnaire.

The success of any empirical research lies in the researcher’s ability to establish a good rapport with their informants (Blix, 2015). According to Cowie et al. (2015), entering the field means gaining access to the research site. The ethical concerns that were considered in carrying out

this study are discussed forthwith. Ethics refers to the system of moral principles by which individuals can judge their actions as right or wrong, good or bad (Denscombe, 2017). He argues that the acceptability of social research depends on the researcher's willingness to accord participants respect and treat them with consideration. Seeking to pursue professional integrity, it was based on the argument that I would obtain consent from those directly involved in this research to respect their autonomy. Participants were fully informed about the purpose of the study, and clarification was given to make them aware of what their participation entailed before they committed themselves (Rallis, 2014). Their participation was voluntary, and if they decided to withdraw from the study at any time, that was without any prejudice. The ethical principle of non-maleficence (no harm to participants), as expounded by Bertram and Christiansen (2014), was considered. In this respect, the researcher guaranteed the confidentiality of information provided by all participants and declared that their contributions to the study would remain anonymous to protect and safeguard their rights, interests, and identity. The researcher also sought ethical clearance for this study from the University of KwaZulu-Natal research department.

4.14 Limitations of the study

Case study findings cannot be generalised, but rich, thick descriptions can be provided so that other researchers can see if the results apply to similar contexts.

4.15 Conclusion

The design and method for data collection and analysis were outlined in this chapter. It detailed collection tools (open-ended questionnaire, focus group interviews and collages) and how they have been used during the data collection process. There are measures described to ensure trustworthiness. The study's data analysis and findings are presented in Chapter 5

Chapter 5
Data analysis and presentation of research findings

5.1 Introduction

This chapter presents and analyses the data collected to address the objectives and research questions of this study. The primary aim is to generate insights that can inform more inclusive and supportive educational practices for female engineering students in the TVET sector.

. The analysis is guided by the following objectives:

1. To establish registered female students' experiences in the various engineering disciplines at a TVET college.

2. To determine how these experiences relate to their participation and performance in these disciplines.

3. To explore the underlying reasons for these experiences in the engineering disciplines at TVET colleges.

Aligned to these objectives, the chapter addresses the following research questions:

1. What are the registered female students' experiences in the various engineering disciplines at a TVET college?

2. How do these experiences relate to their participation and performance in these engineering disciplines?

3. Why do registered female students have these experiences in the engineering disciplines at TVET colleges?

To ensure a clear and systematic presentation of findings, the chapter is divided into three main sections. The first section explores the nature of female students' experiences, drawing on qualitative insights. The second section examines the relationships between these experiences and students' participation and performance, supported by illustrative qualitative data. The third section investigates the underlying reasons for these experiences through qualitative insights supported by themes emerging from interviews and document analysis. Through this

comprehensive analysis, the chapter provides a nuanced understanding of the challenges and opportunities faced by female students in engineering disciplines at TVET colleges, offering critical insights into how these experiences shape their educational and career trajectories. This qualitative approach provides a holistic view of the research problem, setting the foundation for the discussion and interpretations of findings in the subsequent chapter.

5.2 Distribution of participants according to their programmes of study

To support the analysis and interpretation of the data, this section begins with a summary of the participants according to their programme of study. This information is particularly relevant to addressing the research questions, as it highlights the personal and academic contexts that influence the experiences of female students in engineering disciplines at TVET colleges. Table 2 illustrates the academic levels of the participants and the programmes they are enrolled in at a TVET college across two campuses.

Table 5.1 Distribution of participants according to their programmes of study

PARTICIPANTS	ENGINEERING PROGRAMME	CAMPUS	"Moving in"	"Moving through"	"Moving out"
Participant 1	Pre-vocational learning Programmes (PLP)	Campus A	✓		
Participant 2	Pre-vocational learning Programmes (PLP)	Campus A	✓		
Participant 3	Electrical Infrastructure Construction L2	Campus A	✓		
Participant 4	Electrical Infrastructure Construction L3	Campus A		✓	
Participant 5	Electrical Infrastructure Construction L4	Campus A			✓
Participant 6	Mechanical Engineering Fitting and Machining N2	Campus A	✓		
Participant 7	Mechanical Engineering N3	Campus A		✓	
Participant 8	Electrical Engineering N4	Campus A	✓		
Participant 9	Electrical Engineering N5	Campus A		✓	
Participant 10	Electrical Engineering N6	Campus A			✓
Participant 11	Engineering Related Design L2	Campus B	✓		
Participant 12	Engineering Related Design L3	Campus B		✓	
Participant 13	Engineering Related Design L4	Campus B			✓
Participant 14	Mechanical Engineering – Fitting and Machining N2	Campus B	✓		
Participant 15	Mechanical Engineering – Diesel Mechanic N2	Campus B	✓		
Participant 16	Electrical Engineering – N1	Campus B	✓		
Participant 17	Electrical Engineering – N2	Campus B	✓		
Participant 18	Electrical Engineering – N3	Campus B		✓	
Participant 19	Mechanical Engineering – N4	Campus B		✓	
Participant 20	Mechanical Engineering – N5	Campus B		✓	
Participant 21	Mechanical Engineering - N6	Campus B			✓

Table 2 form part of the outline used in the study to analyse the educational progression of participants through different engineering programmes across two campuses, categorised into three key transitional stages: "Moving in," "Moving through," and "Moving out."

Explanation of Columns:

- Participants: Lists the female students in the study, labelled sequentially (Participant 1 through to Participant 21).
- Engineering Programme: Identifies the specific programme each participant is enrolled in, including:

Pre-Vocational Learning Programmes (PLP): Foundational programmes preparing students for vocational training.

Levels 2 to 4 (e.g., *Electrical Infrastructure Construction L2, L3, L4*): Vocational qualifications aligned with the National Qualifications Framework (NQF).

N1 to N6 levels: Further engineering qualifications leading toward higher competency and specialisation.

- Campus: Specifies where participants are enrolled (Campus A or Campus B).
- "Moving in": Indicates whether participants are at the entry or foundation stage of their respective programmes. A checkmark (✓) signifies participation in this initial phase.
- "Moving through": Denotes participants advancing within their programmes, typically in intermediate stages. A checkmark (✓) signifies progression here.
- "Moving out": Represents participants completing their programmes or preparing for workplace integration. A checkmark (✓) indicates readiness to exit.

Campus Distribution:

Campus A primarily accommodates programmes such as *Electrical Infrastructure Construction* and *Mechanical Engineering* across N1-N6 levels.

Campus B caters to similar engineering disciplines but has its own cohort distribution.

Transitions Across Stages:

Some participants start by "Moving in" (e.g., PLP and L2 levels), gaining foundational skills before progressing.

Others transition through “Moving through” (e.g., L3 and N3 levels), reflecting intermediate learning stages.

Finally, participants in “Moving out” (e.g., L4 and N6 levels) are preparing to graduate or enter the workforce.

Educational Pathways:

The table tracks each participant’s progression, highlighting how certain participants follow linear paths (e.g., *Participant 5: L4, moving out*), while others engage at intermediate stages (e.g., *Participant 4: L3, moving through*).

The table further effectively organises data for examining participants’ educational journeys, mapping their transitions, and identifying gaps or patterns in vocational education within South Africa’s engineering sector.

Table 2 above indicates information on the female students as they are “moving in” to the Engineering Programme at a TVET College. Some of the female students are in the “moving through” phase or in a year/middle term in Engineering Studies, and the other female students are in the "moving out" stage/last year/term of study. Six N1 and N2 female students are participating as entry-level students of the R191. Both (N1 and N2) female students fall into the “moving in” category of the research, whereas the NCV entry level is the PLP (Pre-vocational Learning Programmes) and L2. The R191 female students who are in N3-N5 were selected to participate as part of the “moving through” category of the research, and for the NCV programme, only L3 students fall in this category. The NCV L4 and R191, the N6 female students are the exiting students and form part of the moving out category of the research. Ten (n = 10) female student participants are based at Campus A, and eleven (n = 11) are based at Campus B of the sampled TVET college. In engineering studies, there are more registered students at the entry level, which brings about more female student participants on this level. As the students progress to the next level, which is the moving-through stage, there are few. The exit level consists of even fewer students, which resulted in four students participating in the “moving out” stage.

The tables below present the registration data of female student participants per campus, detailing the number of participants enrolled in the NCV and R191 programmes from each

location. This information underscores the geographical and institutional spread of the sample, ensuring a comprehensive understanding of the factors affecting female students' experiences in engineering disciplines.

Campus A registration data

Table 3. Distribution of NCV registration data for Campus A

Campus A – NCV Programmes			
Programme	Registration Period	Total Registered Students	Female students Registered
Pre-Vocational Learning Programme	January-December 2024- Q124	29	5
Electrical Infrastructure Construction NCV L2	January-December 2024- Q124	153	49
Electrical Infrastructure Construction NCV L3	January-December 2024- Q124	50	15
Electrical Infrastructure Construction NCV L4	January-December 2024- Q124	20	7

Table 3 depicts the registration data for Campus A's NCV programmes in 2024, which highlights the participation of female students across various levels. While the Pre-Vocational Learning Programme (PLP) shows a modest enrolment of 5 female students out of 29 total, the Electrical Infrastructure Construction NCV L2 programme demonstrates a relatively higher female representation, with 49 female students registered out of 153 total. This indicates that the entry-level NCV programme may attract more female students than those at higher levels.

However, the progression to advanced levels shows a decline in both total and female enrolment. The Electrical Infrastructure Construction NCV L3 programme registers 15 female students out of 50, and at NCV L4, only 7 female students remain out of 20 in total. This downward trend suggests potential challenges or barriers that may impact female retention as they advance through the NCV levels.

Table 5.2 Distribution of registration data in R191

Campus A – R191 Programmes			
Programme	Registration Period	Total Registered Students	Female students Registered
N1	T124	7	2
N2	T124	148	59
N3	T124	68	27
N4	T124	91	33
N5	T124	84	30
N6	T124	40	12

Table 4 indicates the registration data for Campus A's Report 191 (R191) programmes during the T124 registration period, which shows a notable variation in female participation across levels. Female enrolment is relatively low at the N1 level, with only 2 female students out of 7 total (29%). However, female participation increases significantly at N2, where 59 female students are registered out of 148 total (40%). As students' progress to higher levels, the number of female students gradually decreases, with 27 in N3 (40%), 33 in N4 (36%), 30 in N5 (36%), and 12 in N6 (30%). This downward trend mirrors a broader challenge in retaining female students as they advance through the R191 programme levels, despite relatively consistent proportions.

Table 5.3 Campus B registration data

Campus B – NCV Programmes			
Programme	Registration Period	Total Registered Students	Female students Registered
Engineering-Related Designs NCV L2	January-December 2024- Q124	131	74
Engineering-Related Designs NCV L3	January-December 2024- Q124	72	37
Engineering-Related Designs NCV L4	January-December 2024- Q124	28	14

Table 5 shows the registration data for Campus B's NCV programmes in Engineering-Related Designs, which indicates that female participation is encouraged, particularly at the entry level. At NCV L2, female students comprise 56% of the total enrolment (74 out of 131), indicating strong interest and initial engagement. However, as students progress to higher levels, female representation decreases both in absolute numbers and proportionally. At NCV L3, female students account for 51% of the total enrolment (37 out of 72), and by NCV L4, they represent 50% (14 out of 28). This decline highlights the challenges female students face in advancing through the programme, although their proportional representation remains consistent.

Table 5.4 Campus B – R191 Programme (Mechanical Engineering students only)

Campus B – R191 Programme (Mechanical Engineering students only)			
Programme	Registration Period	Total Registered Students	Female students Registered
N1	T124	04	01
N2	T124	202	77
N3	T124	84	29
N4	T124	101	28
N5	T124	77	27
N6	T124	43	07

The data in Table 6 highlights varying levels of female participation in the R191 Mechanical Engineering programme at Campus B. Female enrolment begins modestly at N1, with just 1 female student out of 4 total (25%). However, participation increases significantly at N2, where 77 female students are registered out of 202 (38%). As the programme progresses, female representation stabilises proportionally but decreases in absolute numbers. Female enrolment is 29 in N3 (35%), 28 in N4 (28%), 27 in N5 (35%), and drops sharply to 7 in N6 (16%). This decline in absolute numbers at higher levels indicates challenges in retention, which merit further exploration.

5.3 Data analysis to respond to research question one

This section presents the findings from the analysis of the open-ended questionnaires and focus group interviews, aimed at addressing *RQ1: What are registered female students' experiences in the various engineering disciplines at the TVET college?*

The responses were analysed using content analysis, where key themes emerged to highlight female students' experiences in engineering disciplines at a TVET college. The analysis focuses on the following overarching themes:

- Motivations for choosing engineering
- Challenges faced by female students
- Support systems
- Overcoming stereotypes
- Financial barriers and resource constraints
- Impact of cultural and social expectations
- Recommendations for enhancing female participation in engineering

Each theme is presented with illustrative quotes from the participants to substantiate the findings. Pseudonyms Candidates 1 to e 21 were used to protect the identities of the participants.

5.3.1 **Theme 1: Motivations for Choosing Engineering**

The findings revealed that female students were drawn to engineering disciplines at TVET colleges primarily due to the practicality of the education offered. This aligns with literature highlighting that TVET institutions are often valued for their focus on skills development and employability. UNESCO (2019) emphasises the role of TVET colleges in providing hands-on training that directly aligns with industry needs, making them particularly attractive to students seeking job-ready qualifications. The participants' appreciation for the practicality of engineering training reflects these findings, as noted by Questionnaire Candidate 1:

Because TVET colleges provide affordable and useful education, I decided to enrol in one.

This perspective is further supported by research from Ismail and Abidin (2022), who found that practical, industry-aligned training was cited by over 70% of female STEM students as a primary motivator for their educational choices. Similarly, McGrath et al. (2020) argue that the practice-oriented nature of TVET education creates a learning environment where students can immediately see the relevance of their studies to real-world applications, which serves as a powerful motivator for persistence.

This underscores the importance of promoting TVET colleges as institutions that bridge the gap between education and employment, particularly for women aiming to enter traditionally male-dominated fields.

Building on the theme of practical education, affordability emerged as another significant factor influencing participants' choice to study engineering at TVET colleges. This finding is consistent with studies by Powell and McGrath (2019), which highlight the financial accessibility of TVET education as a critical enabler for students from low-income backgrounds, especially in developing countries. For female students, affordability often intersects with systematic barriers to accessing higher education in technical fields. As Questionnaire Candidate 7 stated:

TVET colleges provide affordable and useful education, which is why I decided to enrol.

This finding corroborates the results from the focus group interviews. For example, Participant 1 from Focus Group 2 explained:

I wanted affordable, practical education that would lead to good jobs.

The connection between affordability and access is further emphasised in recent research by Olaniran and Mncube (2021), who found that cost-effective technical education serves as a crucial entry point for women from disadvantaged socioeconomic backgrounds. Their study across five African countries demonstrated that when financial barriers are reduced, female enrolment in technical programmes increases by up to 34%. Additionally, Tikly (2023) argues that the affordability of TVET education represents an important mechanism for promoting social mobility and economic empowerment among marginalised populations, particularly women seeking careers in non-traditional fields.

This reinforces the notion that reducing financial barriers is essential to promoting gender equity in STEM fields.

The desire to challenge gender stereotypes and pursue careers in male-dominated fields was a recurring theme in participants' narratives, connecting logically with their pursuit of accessible technical education. This finding resonates with the work of Wang and Degol (2017), who argue that women's participation in STEM is often driven by a desire to break societal norms

and redefine traditional gender roles. Participants expressed pride in their decision to enter engineering disciplines, with Questionnaire Candidate 2 noting:

Female students join engineering to challenge stereotypes.

Such motivations reflect broader efforts to empower women through education, as advocated by the African Union (2015) in its agenda to increase female representation in STEM as a means of fostering social and economic transformation. More recent research by Salleh and Adnan (2022) indicates that women who consciously choose to enter male-dominated fields often become powerful agents of social change, influencing perceptions and creating more inclusive professional environments. Furthermore, Moalosi et al. (2023) found that female engineering students frequently cited "proving women's capabilities" and "being a role model" as significant motivators for persisting in their studies despite challenges.

The importance of this motivating factor cannot be understated, as Arday and Mirza (2021) argue that each woman who successfully challenges stereotypes in technical fields creates a "ripple effect" that encourages others to follow, gradually transforming institutional cultures and practices.

Extending from the theme of challenging stereotypes, the passion for problem-solving and the hands-on nature of engineering training emerged as strong motivators among participants. This finding aligns with studies like those of Margolis and Fisher (2020), which emphasise that women who enter STEM fields often cite an intrinsic interest in problem-solving and innovation as key factors in their decision-making. Questionnaire Candidate 13 shared:

I loved maths and science, and engineering training felt like the perfect way to apply those skills practically.

Questionnaire Candidate 19 added:

Engineering is interesting, and many women like solving problems.

Participant 4 from Focus Group 1 reinforced this perspective:

I realised I was good at Maths and Physics in high school, even though people doubted me.

This intrinsic motivation is further supported by Rozek et al. (2022), who found that women with high self-efficacy in problem-solving abilities were more likely to pursue and persist in engineering fields despite social barriers. Similarly, Dasgupta and Stout (2021) identified that early positive experiences with technical problem-solving create psychological anchors that help women maintain confidence when facing challenges in male-dominated educational environments. Singh and Williams (2023) add that the creative aspects of engineering often underemphasised in public discourse, particularly appealing to female students who seek to combine analytical thinking with innovative design. Such statements underscore the importance of fostering early interest in STEM subjects through hands-on educational approaches, as suggested by Sani et al. (2021).

These interconnected findings suggest that promoting the practicality, affordability, and inclusivity of TVET colleges can further enhance female enrolment in engineering disciplines. Current literature supports the need for targeted outreach and awareness campaigns, as advocated by UNESCO (2022), to emphasise the unique advantages of TVET education for women seeking technical careers.

The multifaceted nature of women's motivations for pursuing engineering at TVET colleges suggests the need for equally multifaceted recruitment and retention strategies. As Chikunda et al. (2023) argue, effective interventions must address both structural barriers (such as affordability and accessibility) and social-psychological factors (including stereotype threat and belonging uncertainty). Their research demonstrates that comprehensive approaches that combine financial support, mentorship, and inclusive pedagogies increase female retention in engineering programmes by up to 45%.

Efforts to highlight the hands-on nature of engineering and its alignment with problem-solving skills may also attract more female students, as these are consistent motivators found in this study and broader research. Kaziboni and Uys (2022) suggest that engineering programmes should emphasise creative problem-solving and real-world applications in their marketing materials, specifically targeting female students, as these aspects resonate strongly with women's reported motivations for entering the field.

Programmes that address affordability and challenge gender stereotypes can further bridge the gap in female participation in male-dominated technical fields. As Ramphele and Thornton (2023) conclude in their comprehensive review of gender inclusion strategies in technical

education, "The path to gender equity in STEM requires both removing barriers and amplifying motivators, making education not only accessible but also appealing to women's diverse interests and aspirations."

5.3.2 **Theme 2: Challenges in academic experiences**

Participants in this study highlighted both positive and challenging aspects of their academic experiences. While many reported constructive interactions with lecturers and reasonable access to resources, two significant challenges emerged from the data: gender-based disparities in practical instruction and limitations in learning resources. These challenges warrant deeper examination as they directly impact female students' engagement and success in engineering programmes.

The findings revealed that while lecture-based instruction was generally perceived as equal, practical sessions often showed gender disparities. Female students reported feeling marginalised during hands-on activities, as illustrated by the following participant statements:

The lecturers are very helpful, especially in explaining hard technical topics. However I noticed that they focused more on male students during practicals. (Focus Group 1, Participant 6)

This observation was echoed in the open-ended questionnaire responses, where Candidate 3 remarked:

Lecturers treat students equally, but female participation can be overlooked at times.

Similarly, Candidate 2 noted:

Lecturers tend to focus more on male students during practical tasks.

These experiences align with broader research on gender dynamics in STEM education. Wang and Degol (2017) emphasise that supportive teacher-student relationships are crucial for retention among underrepresented groups in STEM fields. While participants acknowledged lecturers' willingness to explain challenging concepts, the gender bias observed in practical sessions reflects patterns documented by Bian et al. (2017), who demonstrate how implicit biases create unequal classroom dynamics.

Furthermore, this finding connects to Moss-Racusin et al.'s (2012) research demonstrating that science faculty exhibited subtle but impactful gender biases favouring male students. Also, Cheryan et al. (2017) argue that these classroom interactions constitute "gatekeeping" behaviours that can significantly influence female students' sense of belonging in technical fields. The accumulation of such experiences can lead to what Steele and Aronson (1995) term "stereotype threat," where awareness of negative stereotypes impairs performance.

The second major challenge identified relates to institutional resources. Participants consistently reported that outdated or insufficient practical resources negatively affected their learning experiences, as evidenced by the following statements:

Yes, tools and materials are costly, and the workshop equipment is old. (Focus Group 1, Participant 7)

The workshop does have equipment, but the challenge is that they are old. (Focus Group 3, Participant 1)

"The materials do cost a lot of money". (Questionnaire Candidate 10)

These experiences align with Powell and McGrath's (2019) assertion that resource availability significantly determines the quality of technical education, particularly in resource-constrained environments. The findings also support Marginson et al.'s (2013) argument that material resources are essential for developing practical competencies in engineering education.

Significantly, Mkude and Mhoto (2020) found that resource inadequacies in technical education disproportionately affect female students, who often have less pre-enrolment exposure to technical equipment and thus require more supervised practice time. Le Doux and Waller (2016) further suggest that outdated equipment creates an additional cognitive burden as students must mentally bridge the gap between their theoretical education and contemporary industry standards.

These findings suggest that addressing both interpersonal dynamics (gender bias in instruction) and structural issues (resource limitations) is necessary to improve female students' experiences in engineering education. Faculty development programmes focused on gender-inclusive teaching practices, combined with strategic investment in updated learning resources, could substantially enhance educational outcomes. As Eddy and Brownell (2016) argue, creating

equitable learning environments requires both awareness of implicit biases and concrete institutional support.

5.3.3 **Theme 3 Social and cultural challenges**Female students consistently reported facing gender stereotypes and societal norms that discouraged them from pursuing or fully engaging in engineering disciplines. These experiences align with findings by Wang and Degol (2017), who argue that societal perceptions of engineering as a "male field" create significant barriers to female engagement in STEM. One participant in Focus Group 2, Participant 6 noted:

People think women can't do 'hard' jobs, and this bias is a problem.

Cultural expectations emerged as a powerful factor influencing women's educational choices and experiences in engineering. Participants frequently described social pressure to pursue careers perceived as more "feminine" or to prioritise family responsibilities over academic and professional aspirations. This finding aligns with UNESCO's (2019) observation that cultural beliefs in many regions reinforce the notion that technical and engineering careers are unsuitable for women. For instance, in Focus Group 2, Participant 5 explained:

My family expected me to choose a more 'feminine' career like nursing or teaching.

Such experiences reflect what Sassler et al. (2017) term "gendered socialisation processes" that channel women and men toward different educational and career paths from an early age. Research by Bian et al. (2017) further supports this, suggesting that cultural influences shape gendered career aspirations as early as age six, often discouraging girls from pursuing technical fields before they have had meaningful exposure to them. These cultural barriers are particularly pronounced in engineering, which Cech and Waidzunas (2021) describe as having a persistent "masculine culture" that signals to women that they do not belong to that field. This culture is maintained through subtle cues in language, interactions, and institutional practices that collectively create what Faulkner (2009) terms an "in/visibility paradox" where women are simultaneously highly visible as gender minorities but have their technical competence rendered invisible.

Balancing household responsibilities with academic demands emerged as a significant challenge that disproportionately affected female students. This dual burden often left

participants feeling overextended and negatively impacted their academic performance, as illustrated by the following statements:

It is hard to balance family duties and school. (Focus Group 1, Participant 7)

Doing housework and studying at the same time is hard. But it had to be done. That's how it is at home. (Focus Group 3, Participant 4)

I often feel too tired after chores to study. (Candidate 13)

Yes, household responsibilities limit my study time. (Candidate 21)

These findings align with research by Ferreira (2019), who found that female engineering students in developing contexts spend an average of 18-24 hours per week on domestic responsibilities compared to 5-8 hours for their male peers. Powell and McGrath (2019) similarly highlight that female students in developing regions often face disproportionate domestic workloads, creating a form of "time poverty" that limits their ability to fully engage with educational opportunities.

The combination of cultural expectations and academic pressures creates what Blair-Loy (2003) terms "competing devotions" between family and career schemas, placing women in the position of navigating conflicting societal expectations. O'Meara et al. (2018) argue that these time allocation differences represent a form of "invisible labour" that educational institutions rarely acknowledge in their support structures or policies.

Beyond family expectations, participants also reported broader social perceptions that challenged their legitimacy in engineering fields. As Candidate 4 noted:

Social pressure to stay away from male-dominated fields and get married young.

Similarly, Candidate 1 remarked:

Women are frequently viewed as macho, but I'm disapproving of that.

These comments reflect what Faulkner (2009) describes as the "gender authenticity" dilemma that women in engineering face being perceived as either technically incompetent or socially deviant. Cech (2013) found that this "double bind" forces women to constantly negotiate their

identity in ways that male students do not experience, creating additional psychological burdens. Ettinger et al. (2019) term this the "prove-it-again" phenomenon, where women must repeatedly demonstrate competence that is assumed for their male peers.

The findings highlight the intersectionality of gender and cultural norms in shaping female students' experiences in engineering. According to Margolis and Fisher (2020), cultural and societal structures often perpetuate the belief that technical and engineering roles are inappropriate for women, limiting their access to and success in these fields. Keller and Bridges (2023) extend this analysis to demonstrate how intersecting identities of gender, class, and ethnicity create unique barriers for different groups of women in STEM fields.

This intersectional perspective is crucial for understanding why standard interventions may have limited success. Pawley (2019) argues that many STEM diversity initiatives fail because they treat "women" as a monolithic category rather than acknowledging the diversity of experiences shaped by cultural background, socioeconomic status, and other factors. Ong et al. (2020) similarly emphasise that effective interventions must address the specific challenges faced by women from different backgrounds rather than adopting one-size-fits-all approaches.

Programmes aimed at promoting gender equity in STEM, such as mentorship initiatives and community engagement efforts, have been shown to counteract these barriers (UNESCO, 2022). Dennehy and Dasgupta (2017) found that same-gender mentoring significantly increased female engineering students' belonging, confidence, and retention in the field. Similarly, Stoeger et al. (2019) demonstrated that online mentoring programmes can effectively support women in regions where female role models in STEM are scarce.

Creating inclusive learning environments that challenge cultural norms and provide women with the tools to balance academic and personal responsibilities is critical for fostering equitable participation in engineering disciplines. Research by Hughes et al. (2021) indicates that institutional policies such as flexible scheduling, on-campus childcare, and targeted scholarship programmes can significantly increase the participation and success of women with caregiving responsibilities. Besides, González-Pérez et al. (2020) emphasise the importance of engaging male allies and institutional leaders in creating cultures that value diversity and accommodate different life circumstances.

The dual challenges of gender stereotypes and household responsibilities underscore the systematic barriers faced by female students in engineering disciplines. These findings align with Wang and Degol's (2017) argument that achieving gender equity in STEM requires addressing not only educational barriers but also broader societal norms. To overcome these challenges, a multi-level approach is needed that combines institutional policies (flexible learning options, support services), representation strategies (promoting female role models, creating peer communities), and broader social engagement (community education, family involvement) to transform cultural perceptions about women in technical fields. As Cheryan et al. (2017) conclude, sustainable change requires interventions that address both the structural and cultural dimensions of gender inequality in STEM.

5.4 Analysis to address research question two

This section presents and analyses the data collected to address the second research question, RQ2: How do these experiences relate to their participation and performance in these engineering disciplines? The analysis draws on qualitative data gathered from collage-making and post-collage-making focus group interviews, highlighting how female students' experiences shape their academic engagement and success in engineering disciplines. The discussion focuses on five interconnected themes that emerged from the data: confidence-building through academic achievements, the influence of support networks, challenges posed by gender bias, the balancing of academic and personal responsibilities, and the importance of emotional and mental health support.

Figure 5.1 Collage Presentation

Figure 4 visually represents these themes through participants' collage elements, illustrating the complex interplay between personal experiences and academic outcomes. The collages reveal how participants conceptualise their educational journeys, with visual elements representing both barriers and enablers to their success in engineering.

By examining these interconnected factors depicted in Figure 4, this section aims to uncover how students' lived experiences influence their levels of participation and performance, providing insights into the challenges and opportunities inherent in fostering equitable and supportive learning environments for female students in engineering. These insights align with Bandura's (1986) social cognitive theory, which emphasises how environmental factors interact with personal characteristics to shape behaviour and achievement.

The findings are organised thematically, with each theme supported by illustrative quotes from the participants to ensure their voices remain central to the analysis. This approach offers a nuanced understanding of the interplay between individual experiences and academic outcomes, shedding light on areas for potential intervention and support. As Creswell and Poth (2018) suggest, such phenomenological approaches are particularly valuable for understanding the experiences of marginalised groups within educational settings.

5.4.1 Confidence and belonging through milestones

The transition into engineering disciplines was described as both challenging and transformative for female students. Many participants reported that completing their first year and achieving academic milestones significantly boosted their confidence, reinforcing a sense of belonging. This is consistent with Schlossberg's (1984) Transition Theory, which highlights that milestones within a transition can serve as markers of progress, motivating individuals to continue adapting and thriving in their new environment. One participant in Group 1, Participant 5 remarked:

Finishing my first year proves to me that I belong and can achieve my dreams.

Such experiences highlight the importance of celebrating early academic achievements as a means of building confidence, particularly for underrepresented groups in STEM fields (Wang & Degol, 2017). Carlone and Johnson's (2007) identity development framework further explains this phenomenon, suggesting that recognition of competence, both self-recognition and recognition from others, is critical for students to develop a sustainable science identity. For female students in engineering, successfully completing coursework provides tangible evidence that counters internalised doubts about belonging.

Participating in group projects and practical tasks emerged as a key factor in making female students feel capable and valued. This aligns with Kolb's (1984) experiential learning theory, which emphasises the importance of active engagement in learning activities to build competence and confidence. One participant in Group 2, Participant 3 explained:

Group projects and practical assignments helped me feel more confident and included.

This reflects the findings by Powell and McGrath (2019), who note that hands-on learning in technical education fosters a sense of accomplishment and reinforces students' abilities to apply theoretical knowledge in practical settings. Such experiences are particularly empowering for female students in male-dominated fields, where validation of their skills can help counteract gender-based stereotypes. Hatmaker (2013) further demonstrates that these collaborative experiences serve as "identity workspaces" where female engineering students can negotiate and strengthen their professional identities by demonstrating technical competence to peers and instructors.

Advancing to the second year was described by participants as a symbol of resilience and hard work. For female students in engineering disciplines, progression to the second year represents not only academic success but also their capacity to navigate systematic barriers in male-dominated environments. The excerpts below speak to this view:

Moving to the second year means I'm closer to my dream of becoming an engineer. (Group 3, Participant 4)

This finding echoes Margolis and Fisher's (2020) argument that incremental achievements are essential for retaining women in STEM fields, as they reinforce persistence and long-term goal attainment. Research by Buse et al. (2021) on women's persistence in engineering further indicates that successfully navigating early educational milestones correlates strongly with career persistence, as these experiences build what they term "persistence capital" resources and strategies for overcoming future challenges.

5.4.2 **The role of support networks**

The findings highlight that support from lecturers and peers was instrumental in shaping female students' participation in engineering disciplines. Participants noted that collaborative group work and mentorship were particularly impactful. Similarly, Margolis and Fisher (2020) argue that positive interactions with peers and faculty can significantly enhance the learning experiences of underrepresented groups in STEM, enabling them to build confidence and develop essential skills.

These relationships function as what Wenger (1998) describes as "communities of practice," providing spaces where female students can develop competence and identity through meaningful social interactions. Research by Dasgupta (2011) further explains this phenomenon through the "stereotype inoculation model," suggesting that same-gender peer relationships and mentoring can protect women against negative stereotypes by providing counterexamples that challenge prevailing narratives about women in STEM.

Mentorship and the presence of role models were found to play a pivotal role in helping female students navigate challenges and visualise long-term success. Wang and Degol (2017) suggest that mentorship provides emotional support, career guidance, and a sense of validation for women in STEM, which is critical in overcoming systematic barriers. The following excerpt corroborates this finding:

Having female role models or mentors really helps motivate us. (Group 1, Participant 4)

This aligns with UNESCO's (2022) findings, which highlight the importance of showcasing successful women in STEM to inspire and retain female students. Mentors provide not only guidance but also tangible proof that women can succeed in engineering disciplines, challenging prevailing stereotypes. Lockwood and Kunda (2019) add that seeing successful women who share similar backgrounds can significantly enhance female students' self-efficacy and career aspirations through what they term the "attainable role model effect."

Research by Dennehy and Dasgupta (2017) provides additional evidence for this effect, showing that female undergraduate engineering students paired with female peer mentors reported higher engineering confidence and career aspirations than those paired with male mentors or no mentors. Their longitudinal study reveals that these effects persist over time, suggesting that early mentoring interventions can have lasting impacts on women's participation in engineering.

5.4.3 **The impact of gender bias on classroom dynamics**

Students frequently highlighted that gender assumptions impacted their participation, often leading to a need to "prove themselves" in male-dominated environments. Female students felt they had to work harder to overcome stereotypes. While biases were a source of frustration, they also served as a motivation for some students. Students' views are underpinned by the excerpts below:

*Lecturers should understand that we face unfair assumptions, like being less capable than male students. (*Group 2, Participant 4)

I feel like I need to prove myself, but I'm also proud of my progress. (Group 3, Participant 1)

The findings indicate that female students felt they had to work harder than their male counterparts to counteract stereotypes about women's abilities in engineering. This is consistent with Wang and Degol's (2017) argument that systematic biases in STEM fields often place women in positions where they must continually prove their competence. This phenomenon has been termed the "prove-it-again" bias by Williams et al. (2016), who document how women and other underrepresented groups in STEM must repeatedly demonstrate competence that is assumed for their majority counterparts.

While this pressure was a source of frustration for many participants, some reported that it motivated them to excel academically and professionally. For example, one participant in Group 2, Participant 4 shared:

I use these stereotypes as a challenge to prove them wrong.

This echoes the findings of Margolis and Fisher (2020), who suggest that resilience and determination are common traits among women navigating biased academic environments. This response illustrates what McGee and Martin (2011) term "stereotype management" strategies that minority students develop to navigate and counter stereotypes while maintaining academic achievement. However, Steele and Aronson's (1995) work on stereotype threat suggests that constant vigilance against stereotypes can create cognitive burdens that may detract from academic performance over time.

Research by Cech et al. (2021) further indicates that these experiences create what they term "professional identity tax" additional emotional and cognitive labour required to establish legitimacy in engineering contexts. Their longitudinal studies demonstrate that this tax accumulates over time, potentially contributing to higher rates of attrition among women and minorities in STEM fields. This suggests that while some students may temporarily convert bias into motivation, sustained exposure to biased environments may eventually undermine participation and performance.

5.4.4 **Challenges in balancing responsibilities**

Balancing academic and personal responsibilities was identified as a major challenge that directly impacted students' participation and performance. This aligns with Powell and McGrath's (2019) observation that women in technical education often face disproportionate domestic responsibilities, which can limit their engagement with academic tasks. One participant in Group 3, Participant 5 remarked:

Doing housework and studying at the same time is hard, but it has to be done.

This statement underscores the additional pressures faced by female students, who are often expected to fulfil traditional household roles while pursuing demanding academic programmes. Such dual burdens can lead to stress, fatigue, and reduced academic performance. Blair-Loy's (2003) concept of "competing devotions" provides a theoretical framework for understanding

this tension, highlighting how women navigate culturally powerful schemas that demand total devotion to both family and career.

The following excerpts corroborate the above findings:

Managing your time is super important. The work can be a lot, so balancing school and personal time is key. (Group 1, Participant 3)"

I struggled to balance everything - work at home, schoolwork - and I was always late to class.' (Group 3, Participant 6)

These challenges reflect what O'Meara et al. (2018) term "time allocation patterns" that systematically disadvantage women in academic settings. Their research demonstrates that female students typically spend significantly more time on caregiving and household responsibilities than their male counterparts, creating a form of "invisible labour" that educational institutions rarely account for in their structures and policies.

Research by Weisgram and Diekman (2017) indicates that this conflict between personal and academic responsibilities is one of the primary factors driving women away from STEM fields, as they perceive engineering careers as incompatible with their values and life goals. Their work suggests that communal goal incongruity, the perception that STEM careers conflict with desires to help others and maintain work-life balance, significantly influences women's career decisions and persistence in engineering.

The above findings show that providing flexible academic schedules, time management workshops, and resources like childcare services can improve participation and performance for female students juggling multiple responsibilities. Cohoon (2001) found that institutional practices that accommodate diverse life circumstances significantly improved retention rates among female computer science students, suggesting that structural solutions are essential to addressing these challenges.

5.4.5 **Emotional and mental health support**

Emotional support was a recurring theme in students' reflections on what helped them persist in engineering disciplines. This aligns with Tinto's (1993) theory of student retention, which emphasises the importance of supportive relationships in fostering students' sense of belonging and commitment to their studies. In Group 3, Participant 7 stated:

Talking to someone can really help when things get stressful.

In Group 1, Participant 5 added:

Emotional support is also helpful when dealing with stress, and I think it's a great resource for students.

This reflects the broader recognition in the literature that emotional well-being is a key factor in academic success, particularly in high-pressure environments like STEM education (Wang & Degol, 2017). Research by Jensen and Cross (2021) on mental health among engineering students indicates that women often experience higher levels of stress and anxiety than their male peers, partly due to the additional pressures of navigating hostile environments and managing competing responsibilities.

Students emphasised the importance of having safe spaces to share challenges and seek help. According to Schlossberg's (1984) transition theory, social support is a crucial resource in navigating life transitions, such as entering a male-dominated field like engineering. Participants described the value of peer networks and supportive lecturers in creating environments where they felt heard and understood. One student in Group 3, Participant 5 noted:

It helps me to know that others are going through the same struggles.

This finding aligns with UNESCO's (2019) recommendations for fostering inclusive and supportive environments to improve retention rates among female students in technical fields. Smith et al. (2022) further demonstrate that dedicated affinity groups and peer support networks for women in engineering provide what they term "counterspaces" environments where students can validate each other's experiences, develop coping strategies, and build collective resilience against systemic challenges.

Access to counselling and mental health resources was also seen as crucial in managing stress and maintaining focus. Bandura's (1997) concept of self-efficacy underscores the importance of mental resilience in academic success, suggesting that students who have access to psychological support are better equipped to handle challenges. For instance, Participant 4 in Group 2 stated:

Having someone to talk to about my challenges helps me stay focused on my studies.

This is consistent with the findings of Margolis and Fisher (2020), who argue that providing counselling services in STEM programmes is essential to addressing the unique pressures faced by underrepresented groups, including women. Recent research by Rodriguez and Lehman (2019) demonstrates that targeted mental health interventions for women in STEM can significantly reduce burnout and improve academic outcomes. Their work suggests that addressing both general academic stress and the specific stressors associated with being underrepresented in engineering is essential for supporting female students' well-being and performance.

In summary, the findings highlight that registered female students' participation and performance in engineering disciplines are strongly influenced by the confidence gained through milestones, supportive networks, the challenges of navigating biases, and the burden of balancing personal and academic responsibilities. Addressing these factors holistically can lead to improved engagement and outcomes for female students in engineering programmes.

These findings align with Bronfenbrenner's (1979) ecological systems theory, which emphasises that individual development occurs within complex, interconnected environmental systems. For female engineering students, success depends not only on personal factors but also on supportive microsystems (mentors, peers), accommodating mesosystems (institutional policies), and progressive macrosystems (cultural attitudes about women in engineering). As Main and Schimpf (2017) argue, sustainable improvement in women's participation in engineering requires interventions at all these levels, from individual support to cultural transformation.

The relationships between these themes suggest that institutions seeking to enhance female students' participation and performance should adopt comprehensive approaches that simultaneously build confidence, provide support networks, address biases, accommodate diverse responsibilities, and attend to emotional well-being. As Dasgupta (2011) notes, such multifaceted approaches are most effective when they create "virtuous cycles" where improvements in one area (such as increased confidence) catalyse positive change in others (such as the ability to navigate bias effectively).

5.5 Analysis aimed at responding to research question three

This section presents and analyses the data collected to address the third research question, RQ3: Why do registered female students have these experiences in the engineering disciplines at TVET colleges?

5.5.1 Understanding the Factors Behind Female Students' Experiences

The journey of female students in engineering disciplines unfolds against a complex backdrop of societal expectations, economic realities, institutional structures, and cultural representations. This analysis delves into the multifaceted factors that shape their unique experiences, drawing from the rich narratives shared through open-ended questionnaires and focus group interviews. By examining these accounts, we can trace the interconnected threads of influence that create both barriers and opportunities for women pursuing technical education.

The stories of these students reveal how deeply embedded social norms intersect with practical constraints, institutional practices, and personal responsibilities to create distinctive pathways through engineering education. Their experiences are not merely individual challenges but reflections of broader systemic patterns that require thoughtful intervention. Through their voices, we gain insight into the persistence of gender disparities in engineering and the potential avenues for creating more inclusive technical education.

5.5.2 **Gender Stereotypes and Cultural Norms: The Invisible Boundaries**

The shadow of gender stereotypes looms large over female engineering students, creating invisible boundaries that many must consciously cross. These deeply ingrained societal expectations about women's roles begin shaping perceptions long before students enter technical programmes. As Blickenstaff (2005) observed, these persistent stereotypes effectively designate technical fields as male domains, subtly discouraging women from pursuing careers that challenge traditional gender roles.

The weight of these expectations echoes through students' experiences, as one participant articulated:

People think engineering is not for women, and they expect us to pursue careers like nursing or teaching. (Focus Group 2, Participant 7).

This comment reflects how pervasive societal norms continue to channel women toward care-oriented professions while implicitly suggesting that technical fields lie beyond their natural capabilities or interests.

Religious and cultural beliefs further reinforce these boundaries, as noted by another student:

Religious beliefs sometimes stop women from working in male-dominated fields (Focus Group 3, Participant 1).

These cultural frameworks often prescribe specific roles for women that emphasise nurturing and domestic responsibilities over technical or mechanical work. Cheryan et al. (2017) demonstrated how such cultural messaging creates persistent masculine stereotypes around STEM fields that signal to women they don't belong, affecting interest and participation even before explicit barriers arise.

The persistence of these stereotypes creates ongoing challenges for those who enter engineering programmes.

One student's observation that *People assume that we can't handle technical work because we are women* (Candidate 14) highlights how gender stereotypes don't simply disappear at the classroom door but continue to shape interactions within educational settings. Wang and Degol (2017) emphasise that such stereotypes not only create initial barriers to entry but also undermine women's sense of belonging and self-confidence throughout their educational journey.

These cultural expectations often manifest as family pressure to pursue more "gender-appropriate" careers. The tension between family expectations and personal aspirations creates difficult choices, as explained by one student: *My family wanted me to choose a more 'feminine' career, but I wanted to prove them wron*g (Candidate 8). This determination to challenge stereotypes reflects what Dasgupta (2011) describes in her stereotype inoculation model, which states that overcoming stereotypes requires both personal resilience and supportive counterexamples.

The cumulative effect of these cultural messages creates a pervasive sense of being out of place. As one student observed, it is *hard to feel equal when people around you see engineering as a man's field* (Focus Group 3, Participant 6). This sentiment aligns with Schlossberg's (1984)

transition theory, which emphasises how external influences, including societal norms, fundamentally shape individuals' perceptions of their abilities and opportunities. When the surrounding culture consistently signals that women do not belong to technical fields, each woman must expend additional emotional and psychological energy to maintain her sense of legitimacy.

For some students, these expectations translate into explicit social pressure: *Social pressure to stay away from male-dominated fields and get married young* (Candidate 1). This comment highlights how gender stereotypes in technical education do not exist in isolation but intertwine with broader expectations about women's life trajectories, including pressure towards early marriage and family formation. Master et al. (2016) documented how even subtle environmental cues that reinforce stereotypes can significantly undermine women's interest and sense of belonging in technical fields.

These findings underscore that addressing gender disparities in engineering requires more than removing formal barriers to entry. It demands conscious efforts to challenge stereotypes through representation, education, and community engagement. The persistence of these cultural expectations suggests that creating sustainable change requires intervention at multiple levels, from classroom practices to media representations to community attitudes to reframe engineering as a field where women naturally belong.

5.5.3 **Financial Barriers: The Material Constraints**

Beyond cultural barriers, female engineering students face concrete economic challenges that materially constrain their educational opportunities. These financial obstacles represent a distinct dimension of inequality that intersects with and often amplifies gender-based barriers. Powell and McGrath (2019) noted that financial constraints disproportionately affect marginalised groups in technical education, creating particularly significant hurdles for women from low-income backgrounds.

The practical realities of these constraints emerge clearly in students' accounts: *Tools and materials are very expensive, and this affects our ability to complete practical tasks* (Focus Group 2, Participant 4). This observation highlights how financial barriers directly impact learning opportunities, potentially creating cascading disadvantages as students struggle to fully engage with the hands-on components of their education. When practical experience

forms a crucial part of developing technical competence, limited access to necessary materials can significantly undermine skill development.

While financial aid programmes exist, their implementation often creates additional challenges: *Money is a big problem. NSFAS helps a lot, but the challenge is that it comes very late* (Focus Group 1, Participant 2). This timing gap between when resources are needed and when they become available creates periods of vulnerability that can disrupt educational progress. Stoet and Geary (2018) demonstrated that economic factors play a crucial role in gender disparities in STEM participation, with financial instability creating barriers for women from less advantaged backgrounds.

The impact of these financial barriers extends beyond individual students and affects family decision-making around educational investments. As one participant noted: *There isn't enough financial support for poor families, which stops many girls from trying* (Focus Group 1, Participant 5). This comment illustrates how economic constraints interact with gender stereotypes to shape educational opportunities when resources are limited, and families may prioritise investing in sons' education over daughters', particularly in fields perceived as non-traditional for women. Watt et al. (2017) documented how socioeconomic status intersects with gender to influence educational pathways, with financial considerations often reinforcing traditional gender roles.

Information gaps further compound financial barriers: *My parents were unaware of scholarships* (Candidate 9). This lack of awareness about available resources highlights how access to information represents a critical dimension of educational equity. When financial aid exists but remains unknown or inaccessible, it fails to effectively address the barriers faced by those most in need of support.

These findings suggest that addressing financial barriers requires not only increasing the availability of resources but also improving their accessibility, timeliness, and visibility. Partnerships with industry to provide subsidised tools and equipment could help bridge material gaps, while better information dissemination about available scholarships could ensure that financial support reaches those who need it most. By addressing these concrete economic constraints, institutions can help ensure that talent and determination rather than financial resources determine who succeeds in engineering education.

5.5.4 **Institutional Dynamics: The Learning Environment**

The institutional context in which technical education occurs profoundly shapes female students' experiences, creating environments that can either mitigate or reinforce broader societal patterns. Within this domain, access to mentorship, representation among faculty, and classroom dynamics emerge as particularly significant factors.

The presence of female role models proves especially powerful in shaping students' sense of possibility: *Having female role models or mentors really helps motivate us* (Focus Group 2, Participant 5). This observation aligns with Wang and Degol's (2017) research highlighting how visible representation of women in STEM provides concrete evidence that success is possible, directly countering stereotypes about who belongs in technical fields. As one student specifically noted:

Yes, we have a female lecturer in electrical engineering who really inspires me (Focus Group 1, Participant 7).

The impact of these role models extends beyond simple inspiration. According to Margolis and Fisher (2020), female mentors and instructors provide tangible proof of success, reinforcing the belief that women can excel in engineering disciplines. Also, Espinosa (2011) demonstrates that access to same-gender mentors creates crucial support structures for women navigating male-dominated educational environments, providing both practical guidance and psychological validation.

Yet the institutional environment is not uniformly supportive. Some students observed subtle biases in classroom interactions: *Some lecturers focus more on male students during teaching and practical sessions* (Focus Group 1, Participant 6). This comment highlights how unconscious bias can manifest in everyday teaching practices, potentially creating unequal learning opportunities. Moss-Racusin et al. (2012) documented how faculty may harbour subtle gender biases that advantage male students, even when explicitly committed to gender equity.

These biases often become most evident in hands-on components of education, where assumptions about technical aptitude can shape instructor attention. Powell and McGrath (2019) note that such unconscious biases can subtly influence classroom dynamics, particularly in practical sessions where preconceptions about gender and technical ability may unconsciously guide instructor behaviour.

However, not all students reported bias, suggesting variability across instructors and contexts: *Lecturers prioritise active participation, not gender* (Questionnaire, Candidate 13). This diversity of experience indicates that institutional dynamics are not monolithic but vary based on individual faculty approaches, departmental culture, and specific programmatic contexts.

These findings suggest that creating more supportive institutional environments requires multiple approaches, including expanding mentorship programmes, increasing female representation among faculty, and providing training on inclusive teaching practices. By consciously addressing both representation and interaction patterns, institutions can create learning environments that support the success of all students regardless of gender.

5.5.5 **Balancing Family and Academic Responsibilities - The Double Burden**

For many female engineering students, academic demands represent only one dimension of their daily responsibilities. The challenge of balancing educational commitments with household duties creates a distinctive double burden that shapes their educational journey in significant ways.

Students repeatedly highlighted this challenge in their accounts: *Balancing housework and school is hard, and sometimes I feel too tired to study* (Focus Group 1, Participant 3). This observation reveals how domestic responsibilities can directly impact academic engagement by limiting available time and energy for educational tasks. Powell and McGrath (2019) emphasise that women in technical education frequently shoulder disproportionate domestic responsibilities, creating a systematic disadvantage in educational settings where full engagement is expected.

The inevitability of these dual demands emerged clearly in students' accounts: *Doing housework and studying at the same time is hard, but it has to be done* (Focus Group 3, Participant 2). This resignation to the double burden reflects broader cultural expectations about women's responsibilities, regardless of their educational or professional pursuits. UNESCO (2019) has documented how these societal norms often expect women to prioritise caregiving over personal and professional aspirations, creating persistent barriers to full participation in demanding fields like engineering.

The concrete impact of these responsibilities manifests in limited study time:

Yes, household responsibilities limit my study time. (Questionnaire, Candidate 18).

This constraint on academic engagement represents a tangible disadvantage that can affect performance, particularly in technically demanding disciplines that require substantial practice and study time. Herman and Lewis (2012) document how work-family balance creates particular challenges for women in STEM fields, where intensive time commitments are often expected as proof of dedication.

For many students, the cumulative effect of these responsibilities results in chronic fatigue: *I often feel too tired after chores to study* (Focus Group 1, Participant 4). This fatigue represents more than a temporary inconvenience; it constitutes a persistent barrier to full educational engagement. Xu (2017) established how domestic responsibilities significantly affect women's persistence in STEM fields, creating additional hurdles to completion not faced by their male peers.

These findings suggest that addressing gender disparities in engineering education requires recognising and accommodating the reality of these dual burdens. Institutional support might include flexible scheduling, remote learning options, or campus childcare facilities. More fundamentally, however, these patterns highlight the need for broader social change regarding the distribution of domestic responsibilities, particularly when women pursue demanding educational and professional paths.

5.5.6 **Media and Representation: The Power of Visibility**

The cultural narratives surrounding engineering, who belongs, what the field involves, and what success looks like significantly shape students' perceptions and choices. Media representations and visibility of female engineers emerge as powerful factors influencing how students envision their own possibilities.

Many participants reported limited early exposure to engineering as a career option: *I didn't think about engineering until I saw a TV show about inventors* (Focus Group 3, Participant 7). This comment highlights how media representations can expand awareness of possible career paths, particularly for fields not traditionally associated with women. Blickenstaff (2005) argues that the underrepresentation of women in STEM fields perpetuates stereotypes and discourages young girls from pursuing technical careers, creating a cycle of invisibility.

For some students, media exposure served as a crucial turning point: *As a child, I didn't see myself in engineering. A documentary about women in STEM later inspired me* (Focus Group 1, Participant 4). This observation reflects the power of representation to transform perceptions of what's possible, providing concrete examples that challenge stereotypical assumptions. Smith et al. (2021) documented how media portrayals of women scientists and engineers can significantly influence girls' career aspirations and self-perceptions regarding technical fields.

Students recognise the potential of digital platforms to expand representation: *TVET colleges should share success stories of female engineers on YouTube and Instagram* (Focus Group 1, Participant 3). This suggestion highlights how contemporary media channels offer new opportunities to increase visibility and create counter-narratives to traditional stereotypes. Master et al. (2016) demonstrated how redesigning media messaging about technical fields can significantly reduce stereotype threats and increase women's interest and sense of belonging.

These findings suggest that addressing representational gaps requires intentional efforts across multiple channels, from traditional media to social platforms to institutional communications. By increasing the visibility of women in engineering, these efforts can help create new cultural narratives that normalise female participation in technical fields, expanding the perceived possibilities for future generations of students.

The experiences of female engineering students emerge from a complex interplay of cultural expectations, economic realities, institutional practices, personal responsibilities, and media representations. These interconnected factors create distinctive patterns of opportunity and constraint that shape educational journeys in significant ways.

Gender stereotypes and cultural norms continue to create powerful boundaries, channeling women towards traditional fields and creating psychological barriers for those who pursue engineering. Financial constraints compound these challenges, limiting access to necessary resources and creating difficulties for women from disadvantaged backgrounds. Within educational institutions, representation and interaction patterns significantly influence students' sense of belonging and access to learning opportunities. The double burden of academic and domestic responsibilities creates systematic time and energy constraints that affect educational engagement. Media representations and visibility shape perceptions of possibility, influencing both initial career choices and an ongoing sense of legitimacy within technical fields.

Addressing these challenges requires multifaceted interventions that target both structural barriers and cultural narratives. By increasing representation, challenging stereotypes, addressing financial constraints, accommodating dual responsibilities, and creating inclusive learning environments, institutions can help create educational pathways that support the success of all students regardless of gender. These efforts not only benefit individual women pursuing engineering education but also contribute to building a more diverse and innovative technical workforce.

5.6 Summary of key findings

5.6.1 RQ1: What are registered female students' experiences in the various engineering disciplines at the TVET college?

5.6.1.1 Positive Experiences

- Female students appreciated the hands-on, practical nature of TVET engineering programmes and their affordability.
- Supportive lecturers and some role models inspired students to persist despite challenges.

5.6.1.2 Challenges Faced

- Gender stereotypes and cultural norms often led to biases and exclusion in technical discussions or practical tasks.
- Financial barriers, including the high cost of materials and delayed financial aid, posed significant obstacles.

5.6.1.3 Balancing Responsibilities

- Many students struggled to balance academic demands with household responsibilities, which often impacted their academic performance.

5.6.2 RQ2: How do these experiences relate to their participation and performance in these engineering disciplines?

5.6.2.1 Impact on Confidence and Participation

- Achievements in practical projects and academic success boosted confidence and encouraged active participation.
- Gender bias in classroom interactions often required female students to prove their capabilities, impacting their engagement.

5.6.2.2 Barriers to Performance

- Financial challenges restricted access to essential resources, affecting participation and learning outcomes.
- Emotional and mental stress from balancing multiple roles (student, homemaker, etc.) influenced performance.

5.6.2.3 Role of Support Networks

- Support from peers, mentors, and family played a crucial role in sustaining participation and performance.

5.6.3 RQ3: Why do registered female students have these experiences in the engineering disciplines at TVET colleges?

5.6.3.1 Systemic Gender Bias

- Persistent stereotypes about engineering being a male-dominated field shaped classroom dynamics and societal expectations.
- Cultural norms and religious beliefs discouraged women from pursuing or succeeding in technical careers.

5.6.3.2 Economic Challenges

- Limited financial resources and inadequate funding options created significant barriers for female students.
- High costs of tools and materials further limited access to practical learning.

5.6.3.3 Institutional and Media Influences

- Some institutions lacked sufficient mentorship programmes or inclusive policies to support female students.

- Limited representation of women in engineering in media and outreach programmes impacted students' aspirations and self-belief.

5.7 Applying Schlossberg's transition theory to female engineering students' experiences

Schlossberg's Transition Theory (1981) provides a valuable framework for understanding how female students navigate their experiences in engineering disciplines at TVET colleges. This theory examines how individuals cope with life transitions through four key factors: Situation, Self, Support, and Strategies (the 4S Model).

5.7.1 Situation: Context of the Transition

Schlossberg emphasises that an individual's perception of a transition is influenced by its timing, duration, and concurrent stressors.

The findings of this study confirm these factors as triggers of events

- Entering a male-dominated field represents a significant life transition for female students.
- Timing: "Social pressure to stay away from male-dominated fields and get married young" shows how societal expectations about the appropriate timing for different life events create additional stress.
- Concurrent stress: "Balancing housework and school is hard, and sometimes I feel too tired to study" demonstrates how multiple simultaneous transitions (being a student, managing domestic responsibilities) compound challenges.
- Role change: The shift from traditional female roles to engineering students represents a significant transition requiring identity adaptation.

5.7.2 Self: Personal Characteristics

Schlossberg highlights how personal and psychological resources affect one's ability to cope with transitions. The findings of this study bring to the fore the following self-personal characteristics

- Personal characteristics: "My family wanted me to choose a more 'feminine' career, but I wanted to prove them wrong" demonstrates personal determination in navigating this transition.
- Psychological resources: "Achievements in practical projects and academic success boosted confidence" shows how building psychological capital supports successful transitions.
- Outlook: Female students who persisted despite challenges often demonstrated resilience and optimism, key psychological resources in Schlossberg's model.
- Previous experience: Limited early exposure to engineering ("I didn't think about engineering until I saw a TV show about inventors") meant many students lacked transitional readiness.

5.7.3 Support: Available Resources

Schlossberg emphasises that social support significantly influences transition outcomes.

The findings of this study highlight

- Formal support systems: "Having female role models or mentors really helps motivate us" aligns with Schlossberg's emphasis on institutional support.
- Family support: "Support from peers, mentors, and family played a crucial role in sustaining participation and performance" directly connects to Schlossberg's support factor.
- Institutional support: "NSFAS helps a lot, but the challenge is that it comes very late" highlights how well-timed support is crucial for successful transitions.
- Peer relationships: Support networks among female students likely provided crucial emotional and informational support during this transition.

5.7.4 Strategies: Coping Mechanisms

Schlossberg highlights how individuals manage transitions through various coping strategies. The findings of this study indicate the following coping mechanisms

- Information seeking: "A documentary about women in STEM later inspired me" shows how seeking information and role models serves as a coping strategy.

- Direct action: Female students who actively participated despite bias ("Gender bias in classroom interactions often required female students to prove their capabilities") demonstrated action-oriented coping.
- Inhibition of action: Some students may have withdrawn from full participation as a protective strategy when facing bias.
- Meaning making: Students finding purpose in challenging stereotypes represents cognitive reframing, a key coping strategy in Schlossberg's model.

5.7.5 Transition Outcomes

Schlossberg theorises that successful navigation of transitions depends on the balance between assets (supports and strengths) and liabilities (deficits and challenges). The findings indicate that

- Moving in: Female students entering engineering programmes face challenges related to belonging ("It's hard to feel equal when people around you see engineering as a man's field").
- Moving through: The development of coping strategies and support networks helps students persist despite obstacles.
- Moving out: Academic achievements and practical successes represent successful transition outcomes.
- Transition assessment: The balance between challenges (gender stereotypes, financial barriers, domestic responsibilities) and resources (supportive lecturers, peer networks, personal determination) determines individual transition outcomes.

5.7.6 Implications Based on Schlossberg's Theory

- Strengthen support systems: Develop comprehensive mentoring programmes and peer support networks to enhance the "Support" factor.
- Build psychological resources: Create opportunities for early success to develop confidence and resilience, strengthening the "Self" factor.
- Modify situational factors: Address institutional biases and provide flexible scheduling options to accommodate multiple roles, improving the "Situation" factor.
- Develop coping strategies: Offer workshops on navigating gender bias and balancing multiple responsibilities to enhance the "Strategies" factor.

- Pre-transition preparation: Create outreach programmes that expose young women to engineering earlier, preparing them for this transition.
- Post-transition integration: Develop career transition support to help female graduates navigate entry into the engineering workforce.

This theoretical framing helps explain why some female students successfully navigate engineering education while others struggle, based on their relative balance of transitional assets and liabilities across Schlossberg's 4S factors. Interventions that strengthen these factors would likely improve outcomes for female engineering students at TVET colleges.

5.8 Conclusion

This chapter presented and analysed data collected from open-ended questionnaires, focus group interviews, collage-making, and post-collage-making focus group interviews to address the experiences of registered female students in engineering disciplines at a TVET college. The findings revealed that female students face a complex interplay of societal, economic, and institutional challenges, which significantly influence their participation and performance in these disciplines.

Despite these challenges, female students demonstrated resilience and determination, often leveraging supportive networks and practical successes to sustain their engagement. However, systematic barriers, including gender stereotypes, cultural norms, and financial constraints, remain prevalent, limiting their ability to fully thrive. These barriers are compounded by insufficient institutional support, such as outdated equipment, limited financial aid options, and the lack of structured mentorship programmes.

The findings highlight the critical role of confidence-building experiences, such as completing projects and excelling in practical assessments, in fostering a sense of belonging and improving participation. Additionally, the importance of role models and positive media representation of women in engineering emerged as key enablers of female participation and performance.

Addressing these issues requires a multi-faceted approach that includes promoting gender equity, increasing financial and institutional support, and raising awareness about engineering opportunities for women through media and community outreach. These efforts can help create an inclusive and supportive environment, enabling female students to achieve their full potential in engineering disciplines at TVET colleges.

The next chapter builds on these findings, discussing their implications in the context of existing literature and offering recommendations to enhance female participation and performance in engineering education.

Chapter 6
Discussion of findings, recommendations and conclusion

6.1 Introduction

This study explored the experiences of female students pursuing engineering disciplines at a TVET college, employing Schlossberg's Transition Theory (1981) as a theoretical framework to understand how these students navigate their educational journeys. Guided by three research questions, the study examined the nature of the students' experiences, how these experiences influence their participation and performance, and why these experiences occur. This chapter synthesises the findings, discusses their implications through the lens of Schlossberg's 4S model (Situation, Self, Support, and Strategies), and proposes evidence-based recommendations for institutional practice and policy reform.

The transition into engineering education represents a significant life change for female students that involves adapting to new academic demands while navigating gender-based challenges. Schlossberg's theory provides a valuable framework for understanding how students manage this transition process moving in, moving through, and moving out of engineering education and why some thrive despite obstacles while others struggle. By examining their experiences through this theoretical lens, we can better understand the complex interplay of personal characteristics, situational factors, support systems, and coping strategies that shape educational outcomes.

6.2 Discussion of findings addressing three research questions

6.2.1 RQ1: What are registered female students' experiences in the various engineering disciplines at the TVET college?

The findings revealed a complex mixture of positive experiences and challenges that characterise female students' journeys in engineering education. Through Schlossberg's transition framework, we can understand these experiences as reflecting different aspects of the transition process.

6.2.1.1 Positive Experiences

Hands-on Learning and Affordability: Female students appreciated the practical, hands-on nature of TVET engineering programmes, which made technical education accessible and affordable. This aligns with Schlossberg's "situation" factor, as the practical orientation of the program created a favourable context for learning that accommodated diverse learning styles and economic circumstances.

6.2.1.2 Supportive Lecturers and Role Models

Encouragement from lecturers and the presence of role models inspired female students to persist despite challenges. This represents the "support" dimension of Schlossberg's model, highlighting how institutional and interpersonal support systems facilitate successful transitions by providing emotional encouragement, validation, and guidance.

6.2.1.3 Challenges Faced

Gender Stereotypes and Cultural Norms: These often led to biases and exclusion during technical discussions and practical tasks. Through Schlossberg's framework, this represents a situational barrier that complicates the transition process by creating additional psychological stress and requiring additional adaptive resources.

6.2.1.4 Financial Barriers

The high cost of materials and delays in receiving financial aid posed significant obstacles. This situational constraint limited female students' access to necessary resources, affecting their ability to fully engage with the transition process.

6.2.1.5 Balancing Responsibilities

Many female students struggled to balance academic demands with household responsibilities, which adversely affected their academic performance. This reflects what Schlossberg would categorise as concurrent stress managing multiple transitions simultaneously (female student role and domestic role), which depletes available coping resources.

6.2.2 RQ2: How do these experiences relate to female students' participation and performance in these engineering disciplines?

The impact of these experiences on participation and performance can be understood through how they influence the resources available to female students throughout their transition process, as conceptualised in Schlossberg's framework.

6.2.2.1 Positive Impact

Confidence and Participation - Success in practical projects and academic achievements boosted confidence and promoted active classroom participation. This demonstrates how positive experiences strengthen the "self" factor in Schlossberg's model by enhancing psychological resources such as self-efficacy and optimism, which support successful transitions.

6.2.2.2 Negative Impact

Gender Bias in Classroom - These interactions forced female students to continuously prove their capabilities, sometimes undermining their engagement. Through Schlossberg's lens, this represents a situation that requires ongoing adaptation and depletes psychological resources, potentially hindering a successful transition.

6.2.2.3 Financial Barriers

Restricted access to essential resources due to financial constraints hampered participation and learning outcomes. This situational constraint limited the material resources needed to fully engage with the educational transition.

Emotional and Mental Stress: The strain of balancing multiple roles negatively influenced academic performance. This reflects what Schlossberg would identify as inadequate coping strategies or overtaxed personal resources when facing concurrent transitions.

6.2.2.1 Role of Support Networks

Peer, Mentor, and Family Support - These played a vital role in sustaining female students' participation and academic performance. This directly correlates with Schlossberg's emphasis on the "support" factor as crucial for successful transitions, providing emotional encouragement, practical assistance, and informal knowledge transfer.

6.2.3 RQ3: Why do registered female students have these experiences in the engineering disciplines at TVET colleges?

The underlying causes of these experiences can be understood through Schlossberg's comprehensive view of transitions as influenced by sociocultural contexts, institutional structures, and individual factors.

6.2.3.1 Systemic Gender Bias

Persistent Stereotypes - Engineering as a male-dominated field shaped both classroom dynamics and societal expectations. Through Schlossberg's framework, these represent pre-existing situational factors that influence how the transition is perceived and experienced.

Cultural Norms and Religious Beliefs - These discouraged women from pursuing or excelling in technical careers. These external factors shape the "situation" dimension of the transition, creating additional challenges that require adaptation.

6.2.3.2 Economic Challenges

Limited Financial Resources - High costs and lack of funding for tools and materials created substantial barriers. These situational constraints limited the resources available to support the transition process.

6.2.3.1 Institutional and Media Influences

Insufficient Support Programmes - Despite some college support, there remains a need for sufficient mentorship programmes or inclusive policies. This reflects limitations in the "support" dimension of Schlossberg's model.

Limited Representation - The underrepresentation of women in engineering in media and outreach programmes affected female students' aspirations and self-belief. This influences the "self" factor by shaping female students' perception of possibility and belonging within engineering fields.

6.3 The positive experiences of female students in engineering studies

The study identified several beneficial aspects that significantly influenced female students' educational journeys, which can be understood as facilitating factors in their transition process according to Schlossberg's theory.

6.3.1 Practical and Affordable Learning

TVET programmes' practical components made engineering education more accessible while teaching vital technical skills. Female students' valued seeing theory applied in real-world contexts, which frequently resulted in competency development. Through Schlossberg's lens, this represents a favourable situational aspect that supports transition by making the learning process more concrete and achievable, reducing the intimidation factor often associated with highly theoretical approaches.

6.3.2 Supportive Learning Environment

Encouragement from lecturers, student support services, and the presence of role models proved essential. These elements fostered confidence and a sense of belonging, particularly important in historically male-dominated fields. This directly corresponds to Schlossberg's "support" factor, demonstrating how institutional and interpersonal support systems can significantly enhance transition outcomes by providing encouragement, validation, and practical guidance.

6.3.3 Achievements and Active Participation

Female students' self-confidence strengthened through academic and practical project success, motivating them to engage actively in classroom discussions and group projects. This positive reinforcement cycle resulted in increased involvement and improved performance. This illustrates how successful navigation of transition challenges (what Schlossberg calls "moving through") builds psychological resources in the "self" dimension, creating momentum that supports continued success.

6.4 The constraints of female students in engineering studies

Despite positive aspects, several significant constraints emerged from the study, which can be understood as barriers in the transition process within Schlossberg's framework.

6.4.1 Gender Stereotypes and Cultural Norms

Deep-seated societal expectations and biases affected classroom interactions and technical discussions, forcing female students to continually prove their competence. Through Schlossberg's framework, these represent persistent situational challenges that require ongoing adaptation, potentially depleting psychological resources over time.

6.4.2 Financial Barriers

High costs associated with essential materials and delays in financial aid limited access to necessary resources, affecting both participation and learning outcomes. These situational constraints restricted the material resources needed to fully engage with the educational transition, creating what Schlossberg would identify as a significant liability in the transition process.

6.4.3 Balancing Multiple Responsibilities

The dual burden of academic and household responsibilities led to emotional and mental stress, compromising academic performance. This reflects what Schlossberg categorises as concurrent transitions, managing multiple roles simultaneously, which can overwhelm available coping resources if adequate support and strategies are not available.

6.4.4 Institutional and Media Shortcomings

A lack of structured mentorship programmes, inclusive policies, and positive media representation of women in engineering further reinforced challenges. These limitations in the support environment restricted access to resources that Schlossberg identifies as crucial for successful transitions, particularly role models who demonstrate that success is possible.

6.5 Proposed future work

Future work should address the issues uncovered in the study through interventions that target specific aspects of the transition process as conceptualised in Schlossberg's 4S model: Situation, Self, Support, and Strategies.

6.5.1 Future Work for RQ1: Enhancing Female Students' Experiences

6.5.1.1 Inclusive Curriculum Design

Develop flexible, gender-sensitive approaches that accommodate the diverse needs of female students. Through Schlossberg's framework, this represents modifying the situational aspect of the transition to create more favourable learning conditions.

6.5.1.2 Financial Support Initiatives

Develop scholarships and timely financial aid mechanisms to reduce economic barriers. This addresses situational constraints by ensuring adequate material resources to support the transition process.

6.5.1.3 Awareness Campaigns

Launch initiatives aimed at dismantling gender stereotypes and promoting an inclusive culture within TVET colleges. This intervention targets the broader situational context in which the transition occurs, attempting to reduce bias-related stressors.

6.5.1.4 Enhanced Visibility

Encourage the visibility of successful female engineers through seminars, guest lectures, and media collaborations. This supports the "self" dimension by providing role models that strengthen students' sense of possibility and belonging.

Support for Balancing Responsibilities:

Establish on-campus support services such as childcare and counselling to help students manage multiple roles. This addresses concurrent transitions by providing additional support resources and coping strategies.

6.5.2 Future Work for RQ2: Enhancing Participation and Performance

6.5.2.1 Structured Mentoring

Implement formal mentorship programmes connecting students with experienced professionals in the engineering field. This strengthens the support dimension of Schlossberg's model by providing guidance, encouragement, and professional socialisation.

6.5.2.2 Peer Networking

Foster peer-led study groups and support networks to share best practices and coping strategies. This enhances both the support and strategies dimensions of Schlossberg's framework by creating communities of practice that facilitate knowledge transfer about navigating transition challenges.

6.5.2.3 Addressing Emotional and Financial Stress

Provide counselling services focusing on stress management and mental health support for female engineering students. This intervention strengthens coping strategies while providing emotional support during the transition process.

6.5.2.4 Allocation of Resources

Increase funding for essential resources, including workshop equipment, practical learning materials, and individual student toolboxes. This addresses situational constraints by ensuring adequate material resources to support learning.

6.5.2.5 Combating Gender Bias

Conduct regular training sessions for engineering faculty on inclusive pedagogical practices that actively counteract gender bias in classroom interactions. This improves the situational aspect of the transition by creating more equitable learning environments.

6.5.3 Future Work for RQ3: Understanding the Underlying Causes of These Experiences

6.5.3.1 Longitudinal and Comparative Studies

Undertake research to track changes in female students' experiences over time, assessing the effectiveness of interventions. Expand the study to include multiple TVET colleges and different regions to gain a broader understanding of systemic challenges. This research would provide deeper insight into how transition experiences evolve over time (moving in, through, and out) and vary across different contexts.

6.5.3.2 Investigating Institutional and Media Influence

Examine the impact of existing institutional policies and media representations on female participation in engineering. Test-specific interventions aimed at increasing the representation

of women in media and leadership roles within the engineering field. This research would illuminate how the support environment shapes transition experiences and outcomes.

6.5.3.3 Exploring Cultural and Economic Factors

Conduct qualitative studies exploring how cultural norms and economic challenges shape the experiences of female engineering students. Engage with community leaders, educators, and policymakers to develop culturally sensitive strategies promoting gender equity. This research would deepen our understanding of how situational factors influence transition experiences and identify potential intervention points.

6.6 Limitations of the study

While providing valuable insights, some limitations must be acknowledged: -

6.6.1 Sample Size and Scope

The study was confined to a single TVET college, potentially limiting the generalisability of findings across different institutions or regions. As Hodkinson and Hodkinson (2001) note, case studies are restricted to a single data source, though they can produce rich, thorough data analysis. Consequently, findings should not be generalised to all female engineering students but offer valuable insights into relevant challenges.

6.6.2 Self-reported Data

Reliance on self-reported data may introduce bias, as students might underreport or overstate experiences due to social desirability or recall issues. Through Schlossberg's framework, this represents a limitation in accessing accurate information about the transition experience.

6.6.3 Time Constraints

The cross-sectional nature of the study limited the ability to capture changes in experiences over time. Schlossberg's transition model emphasises that transitions unfold over time (moving in, moving through, moving out), suggesting that longitudinal studies would provide a more comprehensive understanding of the complete transition process.

6.7 Recommendations

Based on findings and analysis, the following recommendations are proposed through the lens of Schlossberg's transition framework:

6.7.1 For Educational Institutions

6.7.1.1 Implement Inclusive Policies

Revise institutional policies to promote gender equity, including flexible scheduling, targeted financial support, and comprehensive mentorship programmes. These changes would enhance the support environment while addressing situational constraints, creating more favourable conditions for successful transitions.

6.7.1.2 Faculty Training

Regularly train lecturers on inclusive teaching practices to mitigate gender bias in classroom interactions. This improves the situational aspect of the transition by creating more equitable learning environments, reducing transition-related stress.

6.7.1.3 Comprehensive Support Services

Develop support services such as childcare, counselling, and academic tutoring to help female students balance academic and personal responsibilities. These services strengthen both support resources and coping strategies, particularly for students managing concurrent transitions.

6.7.1.4 Transition Programmes

Implement structured orientation and transition programmes specifically designed to help female students "move in" to engineering programmes successfully. These programmes should address gender-specific challenges while building community and introducing coping strategies. This directly applies Schlossberg's transition phases to create more supportive entry experiences.

6.7.1.5 Peer Mentoring

Establish formal peer mentoring programmes pairing new female students with experienced peers who can share coping strategies and provide social support. This intervention strengthens

both the support and strategies dimensions of Schlossberg's model, facilitating knowledge transfer about navigating transition challenges.

6.7.2 For Policymakers

6.7.2.1 Targeted Funding

Allocate additional funding to TVET institutions specifically earmarked for programmes supporting female students in engineering disciplines. This addresses situational constraints by ensuring adequate *resources for equity initiatives.*

6.7.2.2 Media Campaigns

Encourage initiatives highlighting successful female engineers through media campaigns and outreach programmes. These efforts support the "self" dimension by providing role models that strengthen students' sense of possibility and belonging.

6.7.2.3 Policy Review

Conduct systematic reviews of policies affecting female participation in TVET engineering programmes, identifying and removing structural barriers. This approach addresses situational factors that complicate the transition process for female students.

6.7.2.4 Early Intervention

Fund programmes introducing young women to engineering concepts and role models before college enrolment. These initiatives prepare potential students for successful transitions by developing interest, confidence, and preliminary skills that Schlossberg would consider pre-transition preparation.

6.7.3 For Future Researchers

6.7.3.1 Longitudinal Research

Pursue long-term studies to assess the impact of various interventions over time. This approach aligns with Schlossberg's emphasis on transitions as processes unfolding over time, providing insight into how experiences evolve through the moving in, moving through, and moving out phases.

6.7.3.2 Comparative Studies

Conduct comparative research across different institutions to better understand regional and institutional variations in experiences. This research would illuminate how different contexts shape transition experiences and outcomes.

6.7.3.3 Intervention Testing

Design and evaluate specific interventions targeting each component of Schlossberg's 4S model (Situation, Self, Support, Strategies) to determine which approaches most effectively support female engineering students' transitions. This theory-driven approach would advance both practical knowledge and theoretical understanding.

6.7.3.4 Transition Analysis

Apply Schlossberg's transition framework explicitly in future studies, examining how female engineering students move through the phases of transition and how their assets and liabilities change throughout this process. This would provide deeper theoretical insight while generating practical knowledge about effective support mechanisms.

6.8 Conclusion

This study has illuminated the complex experiences of female students in engineering disciplines at a TVET college, revealing both significant challenges and potential pathways for improvement. Through the lens of Schlossberg's Transition Theory, we can understand these experiences as reflecting the interplay of situational factors, personal characteristics, support systems, and coping strategies throughout the transition process.

The findings highlight how gender stereotypes, financial constraints, institutional practices, and balancing multiple responsibilities create distinctive transition challenges for female engineering students. Yet they also reveal how supportive lecturers, practical learning approaches, and achievement experiences can build psychological resources that support successful transitions.

By addressing the recommendations outlined in this study, enhancing institutional support, modifying situational constraints, strengthening coping strategies, and building psychological resources, TVET colleges can create more equitable and supportive environments for female engineering students. These changes would not only improve individual educational outcomes but contribute to building a more diverse and innovative technical workforce.

Future research should continue to explore these dynamics through longitudinal and comparative approaches, providing deeper insight into how female students navigate the transition through engineering education and how institutions can best support this process. By understanding and addressing these transition challenges systematically, we can work toward engineering education that fully supports the potential of all students, regardless of gender.

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Appendices

Appendix A Ethical Clearance Letter

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

05 December 2023

Mokgadi Elsa Machaka (221121641)
School Of Education
Edgewood Campus

Dear ME Machaka,

Protocol reference number: HSSREC/00006512/2023
Project title: Unveiling female students' experience in engineering disciplines at a technical and vocational education and training college
Degree: PhD

Approval Notification – Expedited Application

This letter serves to notify you that your application received on 23 November 2023 in connection with the above, was reviewed by the Humanities and Social Sciences Research Ethics Committee (HSSREC) and the protocol has been granted **FULL APPROVAL.**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number. PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

This approval is valid until 05 December 2024.
To ensure uninterrupted approval of this study beyond the approval expiry date, a progress report must be submitted to the Research Office on the appropriate form 2 - 3 months before the expiry date. A close-out report to be submitted when study is finished.

HSSREC is registered with the South African National Health Research Ethics Council (REC-040414-040).

Yours sincerely,

[redacted]

Professor Dipane Hlalele (Chair)

/dd

Appendix B Gatekeeper Letter

higher education & training
Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

westcol
Technical and Vocational Education and Training College

Corporate Office Park: 42 Johnstone Street, RANDFONTEIN; Private Bag X17, RANDFONTEIN, 1760; Tel: (011) 692-4004; Fax: (011) 692-3404; e-mail:ceo@westcol.co.za; website www.westcol.co.za

To : Ms. Mokgadi Elsa Machaka
Student Number: 221121641
36 Pendoring Street
BRACKENDOWNS
ALBERTON SOUTH
1448

Dear Madam

REQUEST FOR PERMISSION TO CONDUCT RESEARCH AT THE INSTITUTION

Permission is granted for you to conduct your research "Unveiling female students' participation in engineering disciplines at a TVET college" at Western TVET college at the Krugersdorp West Campus and Randfontein Campus.

I trust that you will adhere to all ethical protocols, informed consent, anonymity, confidentiality, and participants will not be exposed to any harm.

All the best with your studies

Yours Faithfully

[redacted]

Date: 01/11/2023

Deputy Principal: Academic Affairs

WESTCOL TVET COLLEGE
CORPORATE OFFICE PARK
PRIVATE BAG X 17. RANDFONTEIN 1760
2023 -11- 01
Reg: 03858
TEL: 011 692-4082
FAX: 011 692 4080

College Stamp

Appendix C Letter to Students

Letter of Informed Consent – female engineering student

36 Pendoring street
Brackendowns
Alberton
JOHANNESBURG SOUTH
1448

Dear Participant

INFORMED CONSENT LETTER

My name is Mokgadi Machaka a student studying for PhD - Doctor of Philosophy (Education) at the University of KwaZulu Natal. My research study is titled "Unveiling female students' participation in engineering disciplines at a TVET College". I kindly request permission to conduct research at your institution.

The research will entail collecting data from TVET female engineering students via focus group interviews and open-ended questionnaires. The focus group interviews will be approximately 40 minutes and will be audio recorded. The questionnaire will take approximately 30 minutes to complete. All participants will be assured of confidentiality, and anonymity and that participation is voluntary. Further participants will be informed that they can withdraw from the study at any time without any repercussions. Participants' inputs will not be attributed to them in person but reported only as a population member's opinion. Their involvement is purely for academic purposes only, and there are **no financial** benefits involved.

It is my intention to conduct my research during semesters one and two of 2024 should permission be granted.

Thank you.

ME Machaka (221121641)
Phone Number: 082 589 7746
Email: elsa.machaka@gmail.com

My supervisor is Prof. A Singh-Pillay. Her contact details are:
Email: pillaya5@ukzn.ac.za
Phone number:0844303795
You may also contact the Research Office at:
University of KwaZulu-Natal
Humanities and Social Sciences Research Ethics
Govan Mbeki Centre
Tel +27312604557
Email: HSSREC@ukzn.ac.za
RETURN SLIP

I _____ (Participant name) agree to participate in this study. I fully comprehend the content of the consent letter. I further comprehend what the study is about as explained by the researcher. I understand that I may exercise my right to withdraw from the study at any time.
Participant signature _____
Letter of Informed Consent – TVET engineering lecturer

Appendix D Instruments

SECTION A-BIOGRAPHICAL INFORMATION

PART 1: PERSONAL INFORMATION- FEMALE ENGINEERING STUDENTS

1. Completing the Questionnaire below. Read the questions and answer them honestly to the best of your knowledge. Mark the answer with a tick (✓).

Age	16-35		36-55	

Equity	Black		White		Indian		Coloured	

Position	Student	

Engineering Faculty	NCV	Electrical Infrastructure Construction L2		Electrical Infrastructure Construction L3		Electrical Infrastructure Construction L4	
		Engineering Related Design L2		Engineering Related Design L3		Engineering Related Design L4	
	R191 NATED	Electrical Engineering N1		Electrical Engineering N2		Electrical Engineering N3	
		Electrical Engineering N4		Electrical Engineering N5		Electrical Engineering N6	
		Mechanical (Motor) Engineering N1		Mechanical (Motor) Engineering N2		Mechanical (Motor) Engineering N3	
		Mechanical (Platers/Boilermaker) Engineering N1		Mechanical (Platers/Boilermaker) Engineering N2		Mechanical (Platers/Boilermaker) Engineering N3	
		Mechanical (Fitting) Engineering N1		Mechanical (Fitting) Engineering N2		Mechanical (Fitting) Engineering N3	
		Mechanical (Fitting) Engineering N1		Mechanical (Fitting) Engineering N2		Mechanical (Fitting) Engineering N3	
		Mechanical Engineering N4		Mechanical Engineering N5		Mechanical Engineering N6	

Open Ended Questionnaire: Female Engineering Students

Female students Experiences "moving in" to the Engineering Programme at a TVET college	**1.** You chose "moving into" TVET college as the learning institution of choice, why? Give an example from your life that best demonstrates how you felt as you made the transition from to college. _____
	2. In your opinion, why do female students enrol in engineering disciplines at TVET colleges? _____
	3. What do you think about teachers in classrooms? Do you think they prioritise female students in scientific classes?

	_____ _____
	4. Tell us about a specific instance that best describes your transition to college. How did you feel at the time this occurrence occurred? _____ _____
	5. Did you receive any type of support from any office in the institution? E.g., student support office, administration office or any office you may have been supported for you to cope with your studies. _____ _____
	6. Have you ever received financial assistance before enrolling in engineering studies? _____
	7. Do you think that subjects like science and maths are typically viewed as being more masculine? _____
	8. Are there any financial factors that affected your decision to study engineering studies? _____
	9. Were your parents aware of financial assistance such as scholarships? _____
	10. Do you find learning material and instruments to study engineering studies costly? _____
	11. In your opinion, is there enough financial assistance for poor families in your area? _____

	_____
Female students Experiences "moving through" in a year/term in Engineering Studies at a TVET college	**12.** How did you come to understand your capabilities as a female student in engineering studies? _____
	13. What do you think about teachers in classrooms? Do you think they prioritise female students in scientific classes? _____
	14. Did you receive any type of support from lecturers during teaching and learning in this institution for you to cope with your studies. _____
	15. What enables and or constrains female students' participation and experience as they move through in engineering disciplines? _____
	16. What social challenges do you face that, in your opinion, maybe the cause of your lack of interest in studying engineering at TVET colleges? _____
	17. Are you compelled by any cultural factors to think about enrolling in engineering programmes?
	18. Do you believe that such preconceptions still exist in our culture, and if so, how have they affected you? _____
	19. Did your parents impact your decision to pursue or forego engineering studies? _____
Female students Experiences during the "moving out" stage/last year/term of study	**20.** Is there any social support for females in engineering studies in the last year/term of your studies? _____
	21. Did you receive any form of support from your parents or your family for you to cope with your studies in your last term? _____

	_____
	22. Some communities believe that educating a woman is a waste of time and money. What is your opinion? _____
	23. What steps can you take to put aside these preconceptions if you believe they still exist? _____- _____
	24. Do you believe that the number of hours you spend on housework affects how much time you have for your academic work as a woman? _____
	25. How do you recall growing into your sense of ability as a young girl? Did you think you could pursue an engineering career at that time or were you persuaded by any media? Explain _____
	26. What platform, in your opinion, should TVET colleges offer to encourage female students to study Engineering studies? _____
	27. Any media support for female students as they transition to the engineering industry/workplace? If yes indicate the type of the media and the type of support available in the platform. _____
	28. Would you describe yourself as having a "strong sense of self-confidence" as you complete your engineering studies? If so, do you believe it might have motivated you to pursue an engineering career? _____
	29. Were you in any way affected by beliefs that female students are less qualified as you are completing engineering studies? _____

	30. Now that you are in your last year/term of studies. Do you believe that preconceived notions about gender have impacted your perception of your abilities? If so, how did you conquer these prejudices? _____ _____

FOCUS GROUP INTERVIEWS - FEMALE ENGINEERING STUDENTS

A: To determine the effect of learning factors effects on the enrolment of female students in engineering studies as they move into Engineering studies at a TVET college

1. Why did you select to move into TVET college as your learning institution of choice?
2. Do you believe that subjects like science and maths are often studied by females?
3. Why do female students enrol in engineering disciplines at TVET colleges, in your opinion?
4. How did you come to recognise your potential as a female engineering student?
5. Did any office inside the institution provide you with assistance of any kind?
6. Did the lecturers at this institution offer you any kind of assistance with your learning while you were taking classes there?
7. Do you have any female role model in the engineering studies department?
8. Are there any financial factors that affected your decision to study engineering studies?
9. Do you find learning material and instruments to study engineering studies costly?
10. Have you ever received financial assistance before enrolling in engineering studies?
11. Are poor households in your community receiving adequate financial aid, in your opinion?

B: To determine the effect of social factors effects on the enrolment of female students in engineering studies as they move through their student life

12. What social issues do you currently experience that, in your opinion, may be the reason why you don't want to enrol in an engineering programme at a TVET college?
13. Do you have very little time to dedicate to their academic work given the amount of time you spent doing chores.
14. Do you think that most female learners select courses that other than engineering studies?
15. Which additional cultural elements affect the enrollment of female students in technical institutions in addition to those mentioned above?
16. Females are expected to stay at home, according to culture. What are your thoughts about that?

C: To determine the effect of media factors effects on the enrolment of female students in engineering studies as they move out of the studies

17. Describe a situation that made you more determined to continue your education. What took place? How were you feeling?
18. What media platform, in your opinion, should TVET colleges offer to encourage female students to study Engineering studies?
19. Any media support for female students? If yes indicate the type of the media and the type of support available in the platform
20. How do you recall growing into your sense of ability as a young girl? Did you think you could pursue an engineering career at that time or were you persuaded by any media? Explain
21. Your time and thought are valued. I appreciate your responds to all of my questions.
22. What should I have asked female engineering students that I did not ask?
23. Are there any further comments from female engineering students?

Collage Making

As an engineering student, please make a collage depicting a personal experience. Specifically and clearly recall one outstanding experience as though it were the first time. How did you feel physically while you went through the event? During the encounter, what did you see, hear, feel, and think? Instead of interpreting or discussing the experience, please just express it as you went through it.

Post collage making focus groups interviews: Female Engineering Students

1. Could you describe what it's like to be a student in these conditions as a woman who has finished the first semester of the engineering programme?

2. How do you understand how your experiences before college impacted your first year of the engineering programme?

3. What is the one most crucial fact about being a first-year engineering student that all incoming female students should be aware of?

4. What is the most crucial information that teachers, staff, and administrators at community colleges should be aware of regarding what it means to be a woman enrolled in an engineering programme?

5. What does it mean to you to finish the first year of study and continue to the second year?

6. Do you have anything additional to say regarding the significance you place on your first year of engineering school?

7. Will you encourage more female students in engineering studies?

8. You have been advised about student support service which is available for your emotionally support post collage interviews. Will you use the services?

Appendix E Transcripts

PRESENTATION OF 30 COMPLETED QUESTIONNAIRES DATA

CANDIDATE 1

1. *Because TVET colleges provide affordable and useful education, I decided to enroll in one. I was finally pursuing a hands-on career, so leaving high school seemed exhilarating.*

2. The desire to overcome obstacles and land steady jobs drives female students to pursue engineering degrees.

3. Although we are all treated equally by our teachers, female students occasionally feel left out of technical talks.

4. When I had trouble finding housing, my transfer was difficult. Despite feeling lost, I was inspired to adjust.

5. I did receive assistance from the student support office when I applied for financial aid.

6. No, prior to enrolling, I did not receive any financial aid.

7. They are frequently viewed as macho, but I'm disproving that.

8. My enrollment was delayed by a year due to budgetary difficulties.

9. My parents were unaware about scholarships.

10. The materials do cost a lot of money.

11. No, my town does not have enough financial aid.

12. After performing exceptionally well in practical modules, I became aware of my potential.

13. Despite their best efforts, teachers don't always give preference to women.

14. Yes, lecturers provided supplementary classes and study strategies.

15. Family expectations and a lack of role models limit involvement.

16. Social pressure to stay away from male-dominated fields and get married young.

17. No, I wasn't greatly influenced by cultural elements.

18. Preconceptions do exist, but I have chosen to ignore them.

19. Although they were concerned about my employment prospects, my parents supported my choice.

20. Female engineering students have less social support.

21. My family did provide me with both financial and emotional support.

22. I disagree strongly. Communities are empowered when women are educated.

23. These notions can be contested by increasing awareness and setting an example.

24. It's true that housework has a big impact on my study time.

25. I was inspired by female engineers on television when I was a girl.

26. Provide engineering workshops with a female focus and mentorship.

27. Indeed, female students are inspired and connected by internet platforms such as LinkedIn.

28. My confidence has increased, and it's a major source of motivation.

29. I have encountered peer scepticism, but I have overcome it through perseverance.

30. I was impacted by gender bias, but I overcame it thanks to my perseverance.

CANDIDATE 2

1. TVET College helped me gain practical skills that boosted my confidence.

2. Female students join engineering to challenge stereotypes.

3. Teachers tend to focus more on male students during practical tasks.

4. Adapting to a busy schedule was overwhelming at first.

5. Yes, the student support office helped me with guidance.

6. I paid for my studies with savings.

7. Yes, there are still stereotypes, but opinions are changing.

8. Yes, my parents struggled to pay for my tuition.

9. No, they weren't aware of scholarships.

10. Yes, study materials are very expensive.

11. No, support for poor families is limited.

12. I became more confident after excelling in group projects.

13. No, female students often need to advocate for attention.

14. Yes, lecturers provided feedback and extra resources.

15. Gender stereotypes and financial challenges were barriers.

16. Family pressure influenced my decision to choose a "simpler" career.

17. Yes, progressive family members encouraged me to pursue engineering.

18. Yes, stereotypes exist, but they motivate me to prove them wrong.

19. My parents supported me but were concerned about the challenges.

20. Some support networks exist but are limited.

21. Yes, my family supported me emotionally.

22. Educating women is essential for societal progress.

23. Advocating for gender equality and mentoring others is important.

24. Yes, household responsibilities limit my study time.

25. I admired female engineers I saw on social media.

26. TVET Colleges should create spaces for female innovation.

27. Yes, social media helps inspire and guide me.

28. Yes, I feel confident, which drives my success.

29. Yes, but I've learned to prove my capabilities.

30. Gender bias motivated me to work harder and demonstrate my skills.

CANDIDATE 3

1. TVET College is easily accessible. The transition to it was challenging but rewarding.

2. Female students pursue engineering to challenge norms and explore their interests.

3. Teachers treat students equally, but female participation can be overlooked at times.

4. I was nervous during my first practical session but gained confidence later.

5. Yes, the student support office offered counseling services.

6. Yes, a local NGO helped sponsor my studies.

7. Yes, perceptions are slowly changing.

8. Yes, I needed financial aid for my studies.

9. Yes, my parents helped apply for a scholarship.

10. Yes, tools and textbooks are expensive.

11. No, financial aid is inadequate in my area.

12. I felt capable after achieving good grades in science.

13. No, males often receive more attention in class.

14. Yes, lecturers provided extra sessions for struggling students.

15. Limited mentorship and societal expectations are challenges.

16. Gender stereotypes discourage women from pursuing engineering.

17. No, cultural factors did not influence my decision.

18. Yes, but I've learned to focus on my goals and ignore them.

19. Yes, my family supported me wholeheartedly.

20. Yes, there are workshops for women in STEM.

21. Yes, my family encouraged me.

22. Educating women is crucial for community development.

23. Advocating for gender equality is essential.

24. Yes, household chores limit my study time.

25. I always loved problem-solving and engineering as a girl.

26. Awareness campaigns showcasing successful female engineers would help.

27. Yes, social media platforms inspire me with stories and tutorials.

28. Yes, I feel confident and motivated.

29. Yes, I overcame doubts through persistence.

30. Gender bias pushed me to work harder and prove myself.

CANDIDATE 4

1. I wanted to gain practical skills at an affordable price, and I think its perfect for that. Transitioning was easy because I always knew that's what I want to do

2. Female students study engineering to challenge stereotypes and secure better jobs.

3. Teachers treat all students fairly, but some female students may feel overlooked in science classes.

4. The transition to college was overwhelming initially, but joining study groups helped.

5. Yes, the student support office assisted with adjusting to college life.

6. No, I didn't receive financial assistance before enrolling.

7. Yes, science and math are seen as masculine, but views are changing.

8. Financial reasons influenced my decision, as engineering offers better job prospects.

9. My parents weren't aware of scholarships, which made funding difficult.

10. Yes, learning materials and tools for engineering are costly.

11. No, there isn't enough financial support for poor families in my area.

12. I excelled in practical tasks during workshops, which boosted my confidence.

13. Some teachers don't prioritize female students, but supportive lecturers encouraged us to speak up.

14. Yes, one lecturer provided extra support which greatly helped.

15. A lack of female role models in the field is a challenge.

16. Balancing studies with household responsibilities is exhausting.

17. Yes, cultural factors influenced my decision. My family encouraged me to pursue engineering, like my father's profession as an electrician.

18. I've learned to ignore stereotypes and focus on my goals.

19. My parents were initially hesitant but later supported my decision.

20. No, social support for females in engineering is limited.

21. My family helps with small support like transport money.

22. Education for women is essential for transforming communities.

23. Awareness campaigns can showcase successful female engineers.

24. Yes, housework reduces my study time, but I manage by prioritizing.

25. Seeing a female engineer on TV inspired me to believe I could pursue engineering too.

26. TVET Colleges should create mentorship programmes led by female engineers.

27. YouTube tutorials and social media platforms have helped me develop practical skills.

28. Yes, I've developed strong confidence to aim for leadership roles.

29. Peers doubted my abilities but proving them wrong was empowering.

30. Gender preconceptions affected me, but I overcame them through supportive peers.

CANDIDATE 5

1. TVET College was my only choice because it's affordable and provides practical training. I was overwhelmed you could say, as I wasn't sure if I could afford it.

2. Female students pursue engineering to secure stable jobs and challenge gender stereotypes.

3. Teachers focus on potential, but female students often have to work harder to prove themselves.

4. I felt determined when I managed my finances to register.

5. Yes, the student support office helped me with bursary applications.

6. Yes, NSFAS covered my fees.

7. Yes, and it discouraged me initially, but I've grown stronger.

8. Cost was a major concern.

9. No, I found financial aid on my own.

10. Yes, textbooks and tools are expensive.

11. Financial aid is available but often insufficient.

12. I worked harder to keep up with my peers.

13. Some teachers show bias, but most are fair.

14. Yes, a few lecturers stayed after class to offer extra support.

15. Financial constraints and societal expectations are key obstacles.

16. Family responsibilities often take priority over studies.

17. My family wanted me to choose a "safer" career, but I resisted.

18. Stereotypes exist, but I use them as motivation.

19. My parents discouraged engineering but now fully support me.

20. Yes, the women's network on campus was very supportive.

21. Financial support is limited, but emotional support is constant.

22. Educating women benefits everyone and challenges harmful beliefs.

23. Awareness campaigns and role models can help change perceptions.

24. Yes, housework takes time away from studies.

25. I didn't see myself as an engineer until I excelled in science.

26. More accessible scholarships and mentorship programmes are needed.

27. Online platforms, like LinkedIn, offer valuable opportunities.

28. Yes, resilience has built my confidence.

29. Yes, but I focused on proving them wrong.

30. I've shown my worth through hard work and dedication.

CANDIDATE 6

1. Well it's practical and kept me close to my family. Itwas tough, but my parents' support made it easier.

2. Many female students see engineering as practical and stable.

3. Teachers sometimes favor male students in technical discussions.

4. I felt homesick initially but became more independent over time.

5. The administration office helped with enrollment.

6. No, but my family covered the costs.

7. Yes, and it can discourage some women.

8. Yes, family support helped manage finances.

9. No, we weren't aware of scholarships.

10. Yes, tools and equipment are costly.

11. Support exists, but it's insufficient for families like mine.

12. I succeeded by tackling small challenges step by step.

13. Teachers don't deliberately favor anyone; engagement matters.

14. A few lecturers offered guidance during difficult projects.

15. Family and societal expectations are major constraints.

16. Community pressure pushes women towards traditional careers.

17. No, I was motivated by job security and practicality.

18. I choose to ignore stereotypes and focus on my goals.

19. My parents were hesitant but eventually supported me.

20. Peer networks were minimal, but helpful.

21. Yes, my family kept me motivated.

22. Educating women is essential for societal progress.

23. Dialogue and education can help shift mindsets.

24. Yes, balancing studies with household responsibilities is challenging.

25. I always knew I had potential but needed guidance.

26. More open days for showcasing engineering careers for women would help.

27. No, I haven't come across dedicated platforms.

28. I'm confident, but have worked hard to get here.

29. Yes, but I've learned to block out negativity.

30. I've proven myself through determination and hard work.

CANDIDATE 7

1. I'm the first in my family to attend college, and it was accessible. I felt like I was stepping into the unknown when I was transitioning, it was abit scary

2. Female students see engineering as empowering and a way to challenge stereotypes.

3. Teachers treat students equally, though unconscious bias may exist.

4. I felt excited and determined to break barriers for my family.

5. Yes, the student support office provided a mentor.

6. Yes, a bursary helped cover the costs.

7. Yes, but I push to prove my abilities regardless.

8. Finances were a significant factor; aid made it possible.

9. No, we didn't know about scholarships.

10. Yes, financial aid helped ease the burden.

11. Financial aid is available but not easily accessible.

12. By competing and excelling alongside peers.

13. Teachers prioritize active participation, not gender.

14. Yes, some lecturers were encouraging and supportive.

15. Lack of female representation is a challenge, but peer support helps.

16. Stereotypes about women's roles are discouraging.

17. No cultural influences; my drive comes from within.

18. Stereotypes exist, but I've worked hard to defy them.

19. My parents were initially unsure but trusted my choice.

20. Peer support groups have been essential.

21. Family's emotional support has been invaluable.

22. Outdated mindsets need to change.

23. Educating and leading by example is crucial.

24. Yes, balancing family duties with studies is difficult.

25. I didn't see engineering as a possibility until teachers encouraged me.

26. More outreach programmes for underprivileged communities are needed.

27. Social media platforms and networks support women in STEM.

28. Yes, confidence has developed through overcoming challenges.

29. Yes, but I've shown capability through action.

30. I've proven my community wrong by excelling academically.

CANDIDATE 8

1. My culture discouraged me, but I chose TVET to prove I could succeed. I felt like I was rebelling, but still happy with my decision

2. Many female students pursue engineering to challenge societal norms and prove their worth.

3. Teachers strive for fairness but may have unconscious biases.

4. I felt a mix of fear and pride as I started college.

5. The counseling office helped me adjust.

6. No, I relied on family support.

7. Yes, these stereotypes persist.

8. Financial struggles almost halted my studies.

9. Yes, my parents discovered scholarships through my research.

10. Yes, materials for engineering are costly.

11. Financial aid is insufficient for poor families.

12. By excelling in practical work and exams.

13. Teachers are neutral but may have biases.

14. Yes, inspiring lecturers have kept me motivated.

15. Cultural norms and financial constraints are major barriers.

16. Balancing tradition and ambition is challenging.

17. Yes, but I've pushed against these limitations.

18. Yes, but I've learned to rise above them.

19. My parents were hesitant but are now proud.

20. Alumni networks and women's groups have provided support.

21. Yes, family support has been crucial.

22. That belief is harmful and should be eradicated.

23. Showcasing successful women in STEM can change perceptions.

24. Yes, household duties interfere with study time.

25. A teacher's belief in me sparked my confidence.

26. Partnerships with companies promoting women in STEM are needed.

27. Online resources have been helpful, though no direct platforms exist.

28. Yes, confidence has been key to my journey.

29. Yes, but I've demonstrated capability through action.

30. I've overcome biases by excelling in every opportunity.

CANDIDATE 9

1. I chose TVET College because it offered hands-on engineering experience, and I felt determined to prove myself. It was both exciting and intimidating to transition

2. Female students are passionate about breaking stereotypes and solving real-world problems.

3. Teachers are fair, but female students may need to speak up to be noticed.

4. On my first day, I felt empowered seeing other women, but also a bit intimidated.

5. Yes, the student support office provided resources and emotional support.

6. No, I worked part-time to afford my fees.

7. Yes, I've always believed in equal potential.

8. Financial costs were a challenge, but I managed through budgeting.

9. Yes, but we had to research them independently.

10. Yes, specialised tools are very expensive.

11. Financial aid is available but insufficient in my area.

12. I proved my potential by solving tough problems in class.

13. Teachers focus on engagement, not gender.

14. Yes, lecturers encouraged me during difficult times.

15. Gender stereotypes exist, but mentorship helps overcome them.

16. Balancing studies and family expectations is hard.

17. No cultural pressure, my motivation came from within.

18. Yes, but I've used these stereotypes as motivation.

19. My parents supported my dreams wholeheartedly.

20. Yes, mentorship programmes and alumni networks have been helpful.

21. Emotional and financial support from family has been crucial.

22. Educating women benefits entire communities.

23. Challenge stereotypes through success and advocacy.

24. Yes, household duties take precedence sometimes.

25. Seeing women engineers on TV inspired me as a child.

26. Mentorship and workshops showcasing successful women engineers are needed.

27. Online forums and webinars support young women in engineering.

28. Yes, my confidence grew with every accomplishment.

29. Yes, but I've proven myself repeatedly.

30. Yes, and success is my strongest rebuttal.

CANDIDATE 10

1. I didn’t choose TVET; it was affordable and nearby. Transitioning felt indifferent.

2. Some enroll due to family or teacher encouragement.

3. Teachers focus on the brightest students, regardless of gender.

4. I felt lost during my first week.

5. No, I navigated the system on my own.

6. Yes, a bursary made it possible.

7. Yes, and I used to believe that as well.

8. Money was a significant barrier.

9. No, scholarships weren’t communicated well.

10. Yes, costs are high and burdensome.

11. There’s not enough support for poor families.

12. I proved my ability through trial and error.

13. No, gender doesn’t affect treatment in class.

14. No, lecturers didn’t provide extra support.

15. A lack of role models impacts participation.

16. I faced judgment from peers regarding my career choice.

17. My culture values male-dominated fields.

18. These preconceptions discourage many women, including myself.

19. My parents preferred a more "practical" career path.

20. Minimal social support exists.

21. Emotional support is present, but financial support is lacking.

22. That mindset is outdated and harmful.

23. Education and exposure change perceptions.

24. Housework limits study time significantly.

25. No, I didn’t see my capability until now.

26. Create platforms for networking with female engineers.

27. None that I know of.

28. No, confidence remains a struggle.

29. Yes, and it still affects me.

30. They doubted me, but I’m learning to overcome it.

CANDIDATE 11

1. I've always wanted to create, and TVET College was the perfect place to start. It just felt like I was fulfilling my dream.

2. Female students see engineering as a way to bring unique perspectives to the field.

3. Teachers support everyone equally, but some unintentionally favor males.

4. I felt motivated during orientation by alumni success stories.

5. Yes, mentorship programmes boosted my confidence.

6. No, I relied on family savings.

7. Yes, but I aim to change that mindset.

8. My family's financial stability eased the process.

9. Yes, they guided me through scholarship applications.

10. Yes, but scholarships help alleviate costs.

11. Financial aid could be improved.

12. Winning a class competition proved my abilities.

13. Some teachers encourage women to excel.

14. Yes, especially during difficult projects.

15. Lack of female peers can be isolating.

16. Gender biases are demotivating.

17. No, I was self-driven.

18. I ignored stereotypes and focused on my goals.

19. My parents were neutral but supportive.

20. Yes, alumni groups and networks have been helpful.

21. Yes, through consistent encouragement.

22. It's an outdated belief that impedes progress.

23. Lead by example to inspire change.

24. Balancing is tough but manageable.

25. Media and engineering blogs inspired me.

26. Provide more STEM extracurriculars.

27. Social media mentorship groups exist.

28. Yes, confidence has driven my success.

29. No, I stayed focused on my goals.

30. I've proven my capabilities through persistence.

CANDIDATE 12

1. To inspire others in my community, showing that engineering is a viable option for women. Transitioning felt like a courageous step toward becoming a role model.

2. Female students join to uplift families and break generational poverty.

3. Teachers generally support all students, but sometimes unintentionally focus more on males.

4. I felt both pride and pressure from my community.

5. The administration helped me find financial aid opportunities.

6. Yes, I received a community scholarship.

7. Yes, these stereotypes discourage women from pursuing engineering.

8. Financial struggles almost stopped me, but bursaries helped.

9. Yes, my parents encouraged scholarship applications.

10. Yes, especially for tools and materials.

11. Financial aid exists but isn't enough.

12. Confidence grew through community projects where I applied my skills.

13. Teachers treat students equally but may overlook quieter ones.

14. Yes, a mentor lecturer helped develop my leadership skills.

15. Cultural stereotypes and financial struggles are major barriers.

16. Community pressure to follow traditional roles was difficult.

17. No, I chose engineering despite cultural expectations.

18. I challenge prejudices by excelling academically.

19. My parents were initially skeptical but now support me.

20. Community mentorship programmes have been invaluable.

21. Yes, family support was essential.

22. Educating women benefits the entire community.

23. I mentor younger girls and advocate for gender equality in education.

24. Yes, balancing housework and academics is tough.

25. Seeing engineers on TV inspired me as a child.

26. Leadership workshops for women in engineering should be offered.

27. Social media campaigns promoting women in STEM are useful.

28. Yes, confidence has fueled my success and inspired others.

29. Yes, but I use those doubts as motivation.

30. I've shattered preconceived notions by excelling in practical work.

CANDIDATE 13

1. I loved math and science, so TVET College's hands-on approach to engineering felt right. Transitioning was exciting, like finding where I truly belong.

2. Female students are passionate about solving problems and innovating.

3. Teachers encourage everyone, but male students often dominate discussions.

4. I felt empowered after excelling in my first technical class.

5. Yes, the student support office provided emotional guidance.

6. Yes, NSFAS covered my tuition.

7. Yes, but outdated views are being challenged.

8. Financial challenges were significant; a bursary was essential.

9. No, I found financial aid through personal research.

10. Yes, especially for specialised tools and software.

11. There is assistance, but it doesn't fully meet the demand.

12. I proved my abilities by competing in math and science challenges.

13. Teachers try to balance attention, but louder voices dominate.

14. Yes, a teacher provided additional resources to help.

15. Limited resources and gender biases are barriers.

16. Peer pressure to avoid male-dominated fields was tough.

17. No cultural influences; my passion for it is personal.

18. Preconceptions exist, but I'm proving them wrong through success.

19. My parents fully supported my decision.

20. Yes, clubs for women have provided encouragement.

21. My family supported me emotionally and financially.

22. Women have equal potential; outdated beliefs need to change.

23. Promote female role models through media.

24. Yes, housework reduces my study time.

25. My interest in STEM grew after attending a science camp.

26. Host engineering competitions for women.

27. podcasts have been helpful.

28. Yes, confidence drives my progress.

29. Yes, but I've proven my skills through academic success.

30. I've overcome biases by excelling in technical and leadership roles.

CANDIDATE 14

1. My parents directed me toward TVET College for its stability, though I wasn't passionate about engineering. Transitioning felt like losing control of my future.

2. Many enter TVET influenced by family expectations or financial stability.

3. Teachers are fair, but I didn't feel particularly encouraged.

4. I felt conflicted during my first practical class—it was challenging but rewarding.

5. No, I had to figure everything out independently.

6. Yes, a family friend helped secure a bursary.

7. Yes, which made me hesitant to join engineering.

8. Financial constraints heavily influenced my decision.

9. Yes, my parents helped with scholarship applications.

10. Yes, materials and equipment are costly.

11. Financial aid is limited in my community.

12. I discovered my abilities after completing a challenging project.

13. Teachers prioritise based on effort, not gender.

14. Yes, one lecturer's encouragement changed my perspective.

15. My own doubts were the biggest constraint.

16. I faced pressure to choose a more "feminine" career.

17. Yes, cultural expectations influenced my decision.

18. These beliefs exist, but I've managed to push through them.

19. My parents heavily influenced my choice.

20. No formal support, but classmates provided assistance.

21. Yes, my family supported me throughout.

22. That outdated belief must change.

23. Challenge stereotypes by succeeding in male-dominated fields.

24. Yes, balancing household responsibilities with studies is difficult.

25. I doubted myself but found confidence through practice.

26. More outreach is needed for women hesitant about engineering.

27. No media support available.

28. I'm building confidence, but it remains a work in progress.

29. Yes, but I'm learning to overcome them.

30. I've embraced my strengths and continue to push forward despite doubts.

CANDIDATE 15

1. A fresh start after losing interest in my previous career. Transitioning felt liberating but intimidating.

2. Women enter engineering to challenge themselves and broaden their career options.

3. Teachers support students, but discussions are often dominated by male voices.

4. Receiving my acceptance letter was exciting but came with doubt about switching fields.

5. The student support office guided me through the transition.

6. No, I used my savings to enroll.

7. Yes, society often associates these subjects with men.

8. My previous work experience gave me a financial advantage.

9. No, I found financial aid independently.

10. Yes, some materials are expensive when switching fields.

11. Financial aid exists, but it's not widely advertised for career changers.

12. I realised my abilities through solving real-world engineering problems.

13. Teachers are supportive, but they focus on results.

14. Yes, a lecturer encouraged me to apply previous career skills to engineering concepts.

15. A lack of foundational knowledge initially constrained me.

16. Juggling family responsibilities made focusing harder.

17. No cultural influences—this was a personal decision.

18. Prejudices exist, but as an adult learner, I'm less affected.

19. My parents supported me, but were unsure about my career switch.

20. Informal peer networks provided encouragement.

21. My family helped emotionally during tough times.

22. That belief is outdated; women deserve the same educational opportunities.

23. By excelling and showing others what's possible.

24. Yes, family responsibilities sometimes reduce study time.

25. Exposure to industry stories influenced my decision to pursue engineering.

26. TVET Colleges should offer re-skilling programmes for career changers.

27. LinkedIn and online engineering forums have been helpful.

28. Yes, confidence from previous experiences drives me forward.

29. Yes, but project success helped counter doubts.

30. I've overcome doubts by leveraging past experiences and focusing on strengths.

CANDIDATE 16

1. It offered practical training and was affordable. Transitioning felt overwhelming, as no one in my family had done this before.

2. Female students view engineering as a way to support their families.

3. Teachers are supportive, but quieter students like me are often overlooked.

4. Orientation gave me a mix of pride and anxiety.

5. The administration office assisted with the enrollment process.

6. Yes, I received financial aid through NSFAS.

7. Yes, those stereotypes still deter women from joining.

8. Financial struggles were a key factor in my decision.

9. No, my parents were unaware of financial aid options.

10. Yes, practical equipment is costly.

11. Aid exists, but accessing it is difficult without guidance.

12. I realised my potential after completing a successful project.

13. Teachers are supportive, but male students often take up more attention.

14. Yes, a lecturer helped me understand difficult concepts.

15. Social stereotypes and a lack of family support constrained my progress.

16. Balancing housework and studies was difficult.

17. No cultural factors influenced my decision—this was entirely mine.

18. These beliefs persist, but my academic success has helped overcome them.

19. My parents did not influence my choice; it was my decision.

20. Peer networks provided social and emotional support.

21. My parents supported me emotionally, though not financially.

22. That belief is harmful and must be eradicated.

23. Community education campaigns can challenge stereotypes.

24. Yes, household responsibilities reduce study time.

25. Growing up, I doubted my abilities but gained confidence through academic success.

26. More mentorship programmes would support female students.

27. Social media campaigns featuring female engineers are inspiring.

28. My confidence grows with every academic success.

29. Yes, but I focus on proving myself through achievements.

30. I've overcome biases by consistently demonstrating my skills.

CANDIDATE 17

1. To challenge gender norms in this feild. Transitioning felt empowering, like a personal mission.

2. Women pursue engineering to defy stereotypes and prove their place in STEM.

3. Teachers support students, but gender bias still lingers subtly.

4. Joining my first engineering class felt like a battle to prove myself.

5. The student support office connected me with a mentorship program.

6. No, but I applied for a bursary later.

7. Yes, but views are slowly changing.

8. Financial constraints almost stopped me, but determination pushed me forward.

9. Yes, my parents encouraged me to seek scholarships.

10. Yes, especially for specialised equipment.

11. Financial assistance exists, but it's insufficient for everyone.

12. I discovered my potential through debates and group projects.

13. Teachers strive for inclusivity but could do more to support female students.

14. Yes, a lecturer encouraged me to apply for internships.

15. Gender biases and lack of representation limit many women.

16. Social stigma around women in engineering is challenging.

17. No cultural factors influenced me, but I actively work against these perceptions.

18. Preconceptions exist, but I excel to challenge them.

19. My parents were skeptical but now fully support me.

20. Peer networks have been a great source of support.

21. My family provided emotional support, which made a significant difference.

22. That belief is outdated and harmful.

23. By excelling and mentoring other women in STEM.

24. Yes, managing time effectively has helped.

25. I wanted to challenge traditional roles from a young age, inspiring me to pursue STEM.

26. TVET Colleges should host platforms for women to showcase achievements.

*27. Campaigns like *Girls in STEM* are inspiring.*

28. Yes, my confidence drives me to challenge stereotypes.

29. Yes, but I focus on creating an inclusive environment.

30. I've conquered biases through mentoring and proving my abilities consistently.

CANDIDATE 18

1. For its practicality and affordability, though I didn't initially plan on engineering. Therefore I felt unprepared when I first entered

2. Many women enter engineering through family encouragement or career stability.

3. Teachers aim to be inclusive, but female students are sometimes overlooked.

4. My first practical class made me feel nervous and excited.

5. No, I've navigated things on my own.

6. Yes, I received financial aid from a local charity.

7. Yes, those stereotypes made me question my decision.

8. Yes, financial struggles almost prevented me from enrolling.

9. No, my parents weren't aware of support programmes.

10. Yes, tools and materials are costly.

11. There's some financial aid, but access is challenging.

12. Confidence grew through group projects and peer feedback.

13. Teachers try to balance attention but don't always succeed.

14. Yes, lecturers offered resources and support for difficult topics.

15. Lack of female representation in classes is a major constraint.

16. Social expectations around family roles make balancing studies tough.

17. No cultural influences directly affected my decision.

18. Prejudices exist, but I've learned to manage them.

19. My parents supported me but didn't fully understand my goals.

20. Classmates have been supportive.

21. My family provided emotional support.

22. That belief is incorrect and needs to change.

23. Advocacy and education are key to shifting mindsets.

24. Yes, balancing family duties is hard.

25. I wasn't aware of engineering until seeing women succeed online.

26. Colleges should organise networking events with industry professionals.

27. No media support, but community events help.

28. My confidence is slowly building through consistent effort.

29. Yes, but I rely on my achievements to overcome doubts.

30. I've conquered biases through persistent effort and proving myself consistently.

CANDIDATE 19

1. I chose TVET College to honestly help me get a job quickly. When I first moved into college, I felt nervous. I didn't know what to expect.

2. I think female students choose engineering because it's a growing field with opportunities. Engineering is interesting, and many women like solving problems.

3. I think teachers treat all students equally, but sometimes female students may need extra encouragement in science.

4. A specific moment I remember is during my first practical session. I felt overwhelmed but gained confidence with practice.

5. Yes, the student support office helped me with academic advice, which made it easier to adjust to college life.

6. No, I didn't receive financial assistance before starting my studies.

7. Yes, science and math are often seen as more masculine, but I believe this is changing.

8. Finances were a concern because materials and tools for engineering are costly.

9. My parents were aware of scholarships, but they weren't sure how to apply for them.

10. Learning materials are expensive, especially for engineering, but they're necessary.

11. There isn't enough financial support for poor families in my area, which affects many students' choices.

12. I came to understand my capabilities through practice and support from friends and teachers.

13. I believe teachers try to be fair, but more attention is needed for female students in scientific classes.

14. Yes, lecturers provide guidance and support during class to help us understand complex topics.

15. Social factors like cultural expectations can limit female participation, but support systems can help overcome these challenges.

16. Stereotypes about women being unable to succeed in engineering make me less interested at times.

17. My culture influenced my decision, but I've learned to follow my passion despite expectations.

18. Yes, some stereotypes still exist, but I've learned to focus on my goals.

19. My parents were initially sceptical, but they supported me after seeing my dedication.

20. There is some support in the last term, but more programmes could be introduced for female students.

21. My family provided emotional support, which helped me stay motivated.

22. I believe educating women is important, and it opens doors for a better future.

23. I educate myself and surround myself with positive influences to challenge those beliefs.

24. Yes, housework takes time away from studies, which makes balancing everything difficult.

25. As a young girl, I never thought I could pursue engineering, but media and role models inspired me.

26. TVET Colleges should create mentorship programmes and offer industry visits for female students.

27. Yes, there are platforms that offer advice and support through social media and workshops.

28. Yes, I feel confident in my studies, and it motivates me to continue my journey.

29. No, I believe in my abilities, and such beliefs didn't affect my confidence.

30. In my last term, I realise that stereotypes exist, but my achievements have helped me overcome them.

CANDIDATE 20

1. I chose TVET College because I wanted to fell prepared for the job I want to do and seeing from past friends, it seemed to be the best option for that. I felt excited to start and determined too , but also a little scared to fail, I thought it was much more difficult than high school.

2. Female students enroll in engineering because they are passionate about problem-solving and creating solutions.

3. I think teachers are fair, but sometimes female students need more attention in challenging subjects.

4. A moment I remember is my first group project. I was anxious, but with teamwork, I gained confidence.

5. Yes, the administration office helped with study tips and scheduling, which made my studies easier.

6. No, I didn't receive financial help before college.

7. Yes, science and math are seen as more for boys, but women are breaking those barriers.

8. Finances affected my decision because tools and resources are expensive.

9. My parents knew about scholarships but didn't know how to apply.

10. Engineering materials are costly, but necessary for practical learning.

11. There isn't enough financial support for poor families, which makes it harder for students to focus.

12. I discovered my abilities through practical sessions and constant learning.

13. I believe teachers treat everyone equally, but female students may need more encouragement in scientific subjects.

14. Yes, lecturers provided guidance and helped me manage difficult coursework.

15. Cultural expectations and financial challenges sometimes limit female participation, but support helps overcome them.

16. Social challenges like stereotypes make me feel less confident at times.

17. My culture has shaped my thinking, but I've chosen to pursue engineering despite societal expectations.

18. Yes, stereotypes exist, but they've motivated me to prove them wrong through hard work.

19. At first, my parents were hesitant, but they saw my dedication and began supporting me fully.

20. Last term, there were workshops and forums for female engineering students that helped a lot.

21. My family provided emotional and practical support, which helped me through tough times.

22. Educating women is important for the community's progress, and I believe we should fight against such beliefs.

23. To challenge preconceptions, I participate in awareness programmes and build strong networks.

24. Yes, housework takes time away from my academic work, which is frustrating.

25. Growing up, I never saw engineering as a possibility, but media and mentors helped me realise my potential.

26. TVET Colleges should offer internships and mentorships for female engineering students.

27. Social media and community platforms provide support, but more structured programmes are needed.

28. Yes, I feel confident in my abilities, and this confidence motivates me to pursue engineering further.

29. No, such beliefs did not affect my performance or self-esteem.

30. In my final term, stereotypes exist, but I've proven my worth through my success.

CANDIDATE 21

1. It offered hands-on learning and I am personally more of a practical person than a books one. Moving in, I felt excited but also unsure about how the journey would be.

2. Female students choose engineering because they enjoy problem-solving and contributing to technological advancements.

3. I think teachers treat us equally, but female students may need more support in subjects like science.

4. One instance I remember is during my first lab session. I felt nervous but gained confidence with practice.

5. Yes, the student support office helped me with academic support and time management strategies.

6. No, I didn't receive any financial assistance before starting my studies.

7. Yes, science and math are often seen as more for boys, but more women are succeeding in these areas.

8. Finances were a concern because tools and equipment for engineering are costly.

9. My parents knew about scholarships, but they needed help with the application process.

10. Engineering materials are expensive, but necessary for hands-on learning.

11. There isn't enough financial support for low-income families, which limits access to education.

12. I discovered my abilities through practice and support from peers and lecturers.

13. I believe teachers strive to be fair, but they could offer more encouragement to female students in scientific subjects.

14. Yes, lecturers provided support and helped me navigate through tough coursework.

15. Cultural expectations and financial barriers sometimes hinder female participation, but support networks help overcome these challenges.

16. Social challenges like stereotypes and gender bias can affect interest, but I've learned to stay focused.

17. My culture influenced my thoughts, but I chose to pursue engineering regardless of traditional beliefs.

18. Yes, some stereotypes persist, but I've overcome them through perseverance and achievements.

19. At first, my parents were unsure, but they became supportive once they saw my passion and dedication.

20. In my last term, workshops and mentoring sessions for female students provided significant support.

21. My family provided emotional and practical support, which helped me manage my studies better.

22. Educating women is crucial for society's growth, and I think we should challenge outdated beliefs.

23. To overcome stereotypes, I engage in educational initiatives and build confidence in my skills.

24. Yes, housework takes away time from academic work, but I try to manage it.

25. Growing up, I never thought engineering was for me, but exposure to mentors and media broadened my view.

26. TVET Colleges should provide mentorship programmes and industry exposure for female students.

27. Yes, social media platforms and community workshops offer support, but more structured programmes are needed.

28. Yes, I feel confident in my abilities, which motivates me to continue in engineering.

29. No, I did not face such beliefs as a hindrance.

30. In my final year, stereotypes exist, but my accomplishments have helped challenge them.

GROUP 1

A: To determine the effect of learning factors effects on the enrolment of female students in engineering studies as they move into Engineering studies at a TVET College

1. *I chose a TVET College because it teaches hands-on skills that help you get ready for work. It's cheap and close to where I live.*
2. *No, I don't think so. People often say these subjects are better for boys.*
3. *It's because more people now see that women can do well in jobs usually done by men. Some of us want to prove stereotypes wrong.*
4. *I realised I was good at maths and physics in high school, even though people doubted me.*
5. *Yes, the SSS office helped me choose the right engineering program for my skills.*
6. *For sure! The lecturers are very helpful, especially with explaining hard technical topics. Though I noticed that they expected or focused more on male students during teaching and in practicals*
7. *Yes, we have a female lecturer in electrical engineering who really inspires me.*
8. *Money was a big problem. But NSFAS help a lot, the challenge is that it comes very late*
9. *Yes, the tools and materials are costly. Mostly when I want to start job at home, but the workshop do have the equipment the only challenge is that they are old.*
10. *No, I didn't, but I wish I had more options for financial help. I did not qualify for NSFAS and we are struggling at home*
11. *No, I don't think poor families get enough support, and that stops many young girls from trying.*

B: To determine the effect of social factors effects on the enrolment of female students in engineering studies as they move through their student life

12. *It's hard to balance family duties and school. Many people still think engineering is not for women. I had to do more work at school so that I can cope with family chores*
13. *Yes, I often feel too tired after chores to study.*
14. *Yes, many girls go for jobs with softer skills, like teaching or nursing. I decided to be different*
15. *Yes Ma'am, Some families don't want girls to travel far for school. They worry about safety too. But on my side, I managed to get a room next to the school. I comew from Limpopo.*
16. *I think that belief is old-fashioned. Women can follow their dreams and careers. Like us*

C: To determine the effect of media factors effects on the enrolment of female students in engineering studies as they move out of the studies

17. *I learned a lot during a workshop session. Seeing some of the work I have done in the workshop during internal assessment made me feel proud and confident.*
18. *TVET Colleges should share success stories of female engineers on YouTube and Instagram.*
19. *I haven't seen any yet. An online mentorship program would be a big help.*
20. *As a child, I didn't see myself in engineering. A documentary about women in STEM later inspired me.*
21. *Thank you for listening to what we go through.*
22. *You could ask us how we see the future for women in engineering.*
23. *We need more programmes that support women in technical jobs.*

GROUP 2

A: To determine the effect of learning factors effects on the enrolment of female students in engineering studies as they move into Engineering studies at a TVET College

1. I wanted practical, job-focused training, and TVET was the best option.
2. No, but I've seen more girls becoming interested in these subjects lately.
3. Many of us see it as a way to get better jobs and become independent.
4. My Grade 10 teacher encouraged me after I did well in a bridge-building contest.
5. Yes, the support center helped me with applications and gave me resources.
6. Some teachers go out of their way to help, even offering one-on-one support.
7. No, but I hope to inspire the next generation someday.
8. Definitely. Engineering is expensive, and scholarships are very important.
9. Yes, buying equipment is a big challenge.
10. No, I had to work part-time jobs to save money.
11. No, and I think that's why many girls give up.

B: To determine the effect of social factors effects on the enrolment of female students in engineering studies as they move through their student life

12. People think women can't do "hard" jobs, and this bias is a problem.
13. Yes, taking care of home responsibilities makes it harder to focus on school.
14. Yes, many girls find engineering a bit scary or intimidating.

15. Pressure to marry early and not having female mentors in the community.

16. It's unfair. Women should be able to follow their dreams.

C: To determine the effect of media factors effects on the enrolment of female students in engineering studies as they move out of the studies

17. When I led a group project during internal continuous assessment and it succeeded, I realised I could do great things. Al though I should admit to fear during some of the assessment like geyser connections that needs me to first find it in the roof.

18. Facebook and WhatsApp are popular and easy for people to use.

19. No, but putting up billboards of women in engineering could inspire others. I personally am inspired by ma'am in the workshop.

20. I didn't think about engineering until high school career show where I saw the options.

21. Thanks for letting us share our experiences.

22. What challenges do we face after finishing school?

23. I'd like more study groups for women to help build confidence. I actually enjoyed being part of the group

GROUP 3

A: To determine the effect of learning factors effects on the enrolment of female students in engineering studies as they move into Engineering studies at a TVET College

1. when we came for open learning they told us that TVET Colleges teach practical skills, which is exactly what I wanted.

2. Not really. These subjects are still mostly seen as for boys.

3. Many of us want to break stereotypes and show we can do it. And I still believe that I can do it.

4. I worked on small electrical projects at home and realised I liked it.

5. Yes, the bursary office helped me find ways to pay for school. I am part of NSFAS students

6. Yes, the teachers are friendly and explain things well.

7. Yes, one of the lab assistants is a great female role model. I learn more from her

8. Definitely. I had to think carefully about my money before starting.

9. Yes, tools and books cost a lot. But here at school we have all the equipment we need, some are old. They do not give us tools like other practical subjects, I think if we get opportunity to go home with some of the tools we can expand more in learning

10. No, but I got financial help after I registered.

11. No, there isn't much financial support. Only NSFAS and some of the students are paid for by SETAs.

B: To determine the effect of social factors effects on the enrolment of female students in engineering studies as they move through their student life

12. Gender stereotypes make some girls feel out of place in engineering. I have seen that in most of practical subjects, they lack confidence

13. Yes, doing housework and studying at the same time is hard. But it had to be done, that is how it is at home or maybe let me say my home

14. Yes, many girls choose easier or more familiar courses.

15. Religious beliefs sometimes stop women from working in male-dominated fields.

16. It's restrictive. We need to change these old ideas.

C: To determine the effect of media factors effects on the enrolment of female students in engineering studies as they move out of the studies

17. Completing my first assisgnment made me feel confident.

18. TikTok and YouTube are great for sharing awareness.

19. No, but ads showing female engineers would inspire people.

20. I didn't think about engineering until I saw a TV show about inventors.

21. Thanks for listening to our stories.

22. How can schools help women balance studies and family life?

23. TVET Colleges should host more career events for young girls.

GROUP 4

A: To determine the effect of learning factors effects on the enrolment of female students in engineering studies as they move into Engineering studies at a TVET College

1. I wanted affordable, practical education that leads to good jobs.

2. Not as much as boys, but things are starting to change.

3. More girls now see engineering as a way to break barriers.

4. as an NCV students I discovered my love for mechanical engineering when I joined a school. And I must indicate that some of the courses like N1 to N6 do not have workshop or practical exposure.

5. Yes, the SSS department helps us explore career options.

6. Yes, lecturers motivate us to work together and work on projects.

7. Yes, our program head is an amazing woman who inspires us.

8. Yes, I had to delay my studies for a year because of money problems. I could have completed my studies

9. Yes, engineering equipment and tools are very expensive.

10. Yes, NSFAS bursary helped me start my studies.

11. No, there needs to be more financial support.

B: To determine the effect of social factors effects on the enrolment of female students in engineering studies as they move through their student life

12. My family expected me to choose a more “feminine” career. Like nursing etc, I enjoy my studies in engineering

13. Sometimes, but I have learned to manage my time better.

14. Yes, engineering can feel scary to many girls.

15. People still look down on women working in jobs usually done by men.

16. Culture needs to change to support and empower women.

C: To determine the effect of media factors effects on the enrolment of female students in engineering studies as they move out of the studies

17. Showing my practical assessment was a big moment for me. I hope to be part of world skills south Africa participants in the future

18. YouTube is a great for learning and staying professional.

19. No, but TVET Colleges should start online groups for women in engineering.

20. I’ve always liked electrical engineering , but seeing women electricans online made me more interested.

21. Thanks for letting us share our stories.

22. What support can we get from employers after we graduate? Will they be patient with us R191 students with no exposure to practical’s or workshops

23. More mentorship programmes would help a lot!

Post collage making focus groups interviews: Female Engineering Students				
Interview Questions	*GROUP 1*	*GROUP 2*	*GROUP 3*	*GROUP 4*
1. Could you describe what it's like to be a student in these conditions as a woman who has finished the first semester of the engineering programme?	*CANDIDATE 3- "The first semester was tough but gave me strength. Being a woman here feels inspiring yet lonely since there aren't many of us. I've learned to stay determined and keep going."*	*1. "It's been a wild ride. At first, I didn't feel like I fit in, but group projects/ practical assignments helped me feel more confident and included."*	*1. "The first year has been exciting but stressful. I feel like I need to prove myself, but I'm also proud of my progress."*	*1. "The first year was exciting but also scary. I've had doubts but also found joy in learning new things."*
2. How do you understand how your experiences before college impacted your first year of the engineering programme?	*CANDIDATE 2. -"Before college, I didn't know much about engineering. Coming from a small town with few qualified engineers to help answer the few questions I had for the next phase in my life , I had to work hard to catch up. My first year taught me to stay determined and ask for help."*	*2. "My high school used to show us different shows on career guidance. That experience made solving problems easier in my courses."*	*2. "Growing up in a home with engineers gave me a head start. I knew some basics, which made me feel more confident at the start." They were man though not females.*	*2. "I was good at math, which helped, but I wasn't ready for how hard engineering would be. I had to adapt fast."*
3. What is the one most crucial fact about being a first-year engineering student that all incoming female students	*3. "Managing your time is super important. The work can be a lot, so balancing school and personal time is key."*	*3. "Don't be afraid to ask questions. It might feel awkward, but it helps you and others who are unsure too."*	*3. "Make friends with your classmates and older students. Building these connections helps you face challenges together."*	*3. "Be ready to work harder than ever before. But remember, your effort will be worth it."*

should be aware of?				
4. What is the most crucial information that teachers, staff, and administrators at community colleges should be aware of regarding what it means to be a woman enrolled in an engineering programme?	*4. "Lecturers should know we deal with stereotypes and need support. Having female role models or mentors really helps motivate us."*	*4. "lecturers should understand that we face unfair assumptions, like being less capable than male students. Encourage everyone equally and make the class welcoming."*	*4. "Colleges need to ensure we feel safe and supported. Creating mentorship programmes for women would be really helpful."*	*4. "Colleges need to make classrooms welcoming and ensure everyone, no matter their gender, has the resources they need."*
5. What does it mean to you to finish the first year of study and continue to the second year?	*5. "Finishing my first year proves to me that I belong and can achieve my dreams."*	*5. "I'm proud of myself! Moving to the second year shows I've overcome fears and built a strong base for the future."*	*5. "Moving to the second year means I'm closer to my dream of becoming an engineer. It's proof that my hard work is paying off." I would like to go to university after completing college*	*5. "Moving to the second year shows I can succeed in engineering. It's proof of my hard work and determination."*
6. Do you have anything additional to say regarding the significance you place on your first year of engineering school?	*6. "The first year taught me to be strong. Every challenge I faced showed me that engineering is my passion."*	*6. "The first year taught me to work well with different people, a skill that will help me in my career."*	*6. "The first year made me sure I love engineering. It also taught me the value of pushing through tough times." Let me tell everyone the truth I struggled to balance everything work at home, school work and I was*	*6. "The first year was a time of growth. I learned a lot about my strengths and areas I need to improve."*

			always late in class	
7. Will you encourage more female students in engineering studies?	*7. "Yes! More women need to see that they can do engineering. I've already started encouraging high school girls to try it."*	*7. "For sure! Engineering needs more diversity, and I want to inspire others to succeed here too."*	*7. "Yes! More women need to know they can succeed in this field."*	*7. "Yes! It's important for more women to join. Together, we can build a stronger engineering community."*
8. You have been advised about student support service which is available for your emotionally support post collage interviews. Will you use the services?	*8. "Definitely. Emotional support is so helpful when dealing with stress, and I think it's a great resource for students."*	*8. "Yes, I would use those services if I needed them. Mental health is important, especially in such a demanding field." I felt that I did not fit in during the fault-finding project. My lecturer and other peers supported me a lot to*	*8. "Yes, I'd use those services. Talking to someone can really help when things get stressful."*	*8. "Yes, I would use SSS services. Taking care of your mental health is important for doing well in school."*

Appendix F- Editing

Independent Editor

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CERTIFICATE OF EDITING

This confirms that I edited substantively the document below, including a Reference list. The document was returned to the author with various tracked changes to correct errors and clarify meaning.

TITLE: **Unveiling female students' experiences in engineering disciplines at a technical and vocational education and training (TVET) college**

AUTHOR : **Mokgadi Elsa Machaka**

STUDENT NUMBER : **221121641**

Note: The edited work described here may not be identical to that submitted. The authors, at their sole discretion, have the prerogative to accept, delete, or change amendments made by the editor before submission.

DATE: **11 April 2025**

EDITOR'S COMMENT

The author was advised to effect suggested corrections regarding subject-verb agreement, punctuation and overall academic writing style, to name a few.

[redacted]

Signature

Dr Kufakunesu Zano, PhD in English. A member of the South African Translators' Institute, Ref 1000686, South Africa 2025

Appendix G Turnit in

Document Viewer

Turnitin Originality Report

- Processed on: 18-Apr-2025 6:54 AM CAT
- ID: 2647966547
- Word Count: 36835
- Submitted: 2

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