# The role of educational technology as an enabler for women's inclusion in the STEM fields:
# Case study: Eduardo Mondlane University

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## Abstract

Current research shows that women are underrepresented in STEM fields, despite a global increase in enrolment over the past two decades. At Eduardo Mondlane University (UEM), women make up only 15% of engineering students. This underrepresentation is linked to deep-rooted social injustices, making it a systemic issue. Scholars argue that technology can promote more inclusive education by providing greater opportunities for women in STEM. However, in the Mozambican context, research about educational technology (EdTech) as a tool for fostering women's inclusion, particularly in the STEM education field, is scarce. Therefore, this study seeks to contribute to the discussion on the underrepresentation and the inclusion of women in the STEM field of education with a particular focus on UEM's engineering undergraduate courses. In this research, a qualitative approach was used to understand whether technology in the engineering graduate course's classroom at UEM can have an enabling and inclusive effect by providing a potential mechanism for women to participate in the learning process as equal peers. The study engaged with six UEM female students through eighteen in-depth interviews (three interviews per participant). The interviews were conducted using Seidman's (2013) three-interview protocol. The results were analysed and framed using the work of Nancy Fraser, who presents a three-dimensional social justice framework (economic, cultural, political) (2005, 2009). Fraser's framework was used to analyse the results and understand to what extent EdTech can be an enabling factor to achieve social justice in the university context of engineering graduate courses. This research found that women prefer in-person classes, but they also benefit from educational technologies, appreciating the flexibility of asynchronous online activities due to their limited time, often stretched between academic pursuits and domestic responsibilities, which are culturally expected to be managed primarily by women. Moreover, for these women, in a digital environment, there is a reduced presence of conventional gender biases and expectations to fit in related to physical appearance and adoption of male behaviours, enabling women to genuinely express their character and make authentic contributions.

Keywords: women, STEM, underrepresentation, educational technology, EdTech, social justice, participatory parity, inclusion.

**Dedication**

To Nino Remane, my husband, and to our children, Avye and Azli Remane: Your love and constant support have illuminated my path. I could never have understood the real meaning of living a worthwhile life without you. Every step of this journey reflects the profound impact you have had on my existence.

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Lastly, I owe a great debt of thanks to Sweden's Government Agency for Development Cooperation (SIDA) and the Program Support Unit at UEM. I will always be appreciative of these organisations for their scholarships, which have made it possible for me to continue my education.

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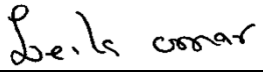
Signature:  Date: July 2024

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# List of Abbreviations and Acronyms

| | |
|---|---|
| ARA-W | African Research Academies for Women |
| EdTech | Educational Technology |
| HE | Higher Education |
| ICT | Information and Communication Technologies |
| LMS | Learning Management System |
| OECD | Organization for Economic Cooperation and Development |
| OER | Open Educational Resources |
| PLA | Participatory Learning and Action |
| STEM | Science, Technology, Engineering and Mathematics |
| TIC-EID | Department for ICTs in Education Research and Development |
| TL | Teaching and Learning |
| UCT | University of Cape Town |
| UEM | Eduardo Mondlane University |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| UNICEF | United Nations International Children's Emergency Fund |
| YWISE | Young Women in Science and Engineering |

# 1. Chapter 1: Introduction

This study aims to investigate the potential of technology to create a more equitable learning environment for female students in science, technology, engineering, and mathematics (STEM) fields, with a focus on the Faculty of Engineering at Eduardo Mondlane University (UEM). Ultimately, it seeks to contribute to the discussion on addressing the underrepresentation of women in STEM education.

It is indisputable that women are underrepresented in STEM fields, with numerous factors contributing to this disparity (Kenney et al., 2012). The educational paths students choose are heavily influenced by gender stereotyping and gendered expectations, leading to disparities in skills and participation in STEM fields based on perceived competence rather than actual ability (OECD, 2017).

Inclusion is crucial for reducing underrepresentation in STEM fields, as disparities persist not only due to access issues but also due to a lack of inclusive practices that address the diverse needs of underrepresented groups. Effective inclusion transcends numerical representation and creates environments where all individuals, regardless of race, gender, or background, feel valued and have equal voices and opportunities to thrive. While much research on educational inclusion focuses on disabilities (Hernández-Saca et al., 2023; Rademaker et al., 2020), it often overlooks other crucial aspects, such as gender disparities in STEM. Addressing women's specific inclusion needs is essential to foster a truly diverse and equitable academic environment (Musara et al., 2020).

The concept of inclusion in education involves diverse interpretations and implementation challenges, emphasising the need for multidimensional approaches like systems theory to operationalise inclusion (Qvortrup & Qvortrup, 2018). In Mozambique, research highlights a significant gap in understanding the barriers women face in STEM, often focusing on quantitative aspects like enrolment statistics while neglecting qualitative experiences (Commodore-Mensah et al., 2020; Uamusse et al., 2020). Addressing these gaps requires comprehensive interventions that support women's participation and success in STEM, including providing role models and mentors (Dzisi et al., 2022). Creating a supportive community and addressing barriers at systemic and localised levels can transform societal attitudes and enhance women's contributions to STEM in Mozambique (Casad et al., 2020; Owuondo, 2023).

## 1.1. Research Context and Rationale

As a lecturer and former student at the Faculty of Engineering at UEM, I observed the low representation of women. As an undergraduate, there were just two females in a class of forty. Nine years later as a lecturer, this trend persists. I've also noted, anecdotally, the limited participation of females in learning activities, contrasted with more active engagement from male students.

Madara and Cherotich (2016), in their study on challenges for female engineering students, emphasise the need for strategies to enhance the learning environment and boost course completion rates. They also stress the importance of developing support and mentoring activities for female students at engineering schools to ensure an appropriate educational experience.

Many authors worldwide have emphasised technology's role in learning to promote more inclusive education (Khan, 2018; Laurillard et al., 2018; Méndez et al., 2023; Omosebi & Motunrayo, 2021; UNICEF, 2021). However, in Mozambique, the use of educational technology (EdTech) for fostering women's inclusion in STEM is limited. UEM, Mozambique's oldest and largest university, often leads by example. Understanding how EdTech can increase minority participation in STEM classrooms could benefit not only UEM but also other institutions in Mozambique.

I am driven to explore EdTech at UEM to enhance women's inclusion, leveraging my information and communications technology (ICT) experience in developing educational software. My interest in identifying effective practices for technology integration, like mechanisms for equal participation of female students in STEM, stems from my personal experience as a woman in STEM and as a female student in a male-dominated field. As a STEM educator, I am committed to ensuring my students have a positive educational experience. This study seeks to understand whether educational technologies in the STEM field can have an inclusive effect especially focused on fostering women's representativeness in STEM education at UEM.

## 1.2. Research Objectives

The purpose of this research, through a qualitative approach, was to explore the role of educational technologies in fostering women's inclusion in engineering at UEM, enabling them to participate as equal peers and have their voices heard. Drawing on empirical data collected from interviews with six individuals, this study not only investigated the social injustices faced by female students in engineering but also aimed to contribute findings on how educational technologies could be used to mitigate these injustices.

Specifically, this research examined the use of EdTech to promote equitable access to resources and opportunities for female engineering students. It assessed the potential of EdTech to foster an environment where the identities and experiences of female engineering students are respected and recognised. Additionally, the study explored strategies to enhance female engineering students' visibility and representation through EdTech.

## 1.3. Research Problem

Women's under-representation in STEM higher education (HE) remains a persistent global concern (Casad et al., 2020; Hoyer, 2024; Kahn & Ginther, 2017; Madara & Cherotich, 2016; Owuondo, 2023). Madara and Cherotich (2016) recognised the importance of gender diversity in STEM. Gender inequality, which persists globally, impacts all aspects of life by reducing women's presence in key roles and diminishing their voices in vital decisions (OECD, 2017). A balanced gender population is crucial for tackling global challenges (Gabriel, 2017; Ghebreyesus, 2017).

Innocent and Kipene (2022) noted that, at Mbeya University of Science and Technology, Tanzania, female ICT enrolment was just 2%, significantly lower than in fields like business administration, where it reached 45%. These women reported feeling discouraged from pursuing ICT due to gender stereotypes, financial constraints, and a lack of female role models. Despite equal access to entry and participation in any learning programme, a significant gender gap remains. In the specific case of the Engineering Faculty at UEM, the population of female students does not exceed 14% (Fig. 1), and this percentage has remained the same over the past years (UEM_GAPQEI, 2021).

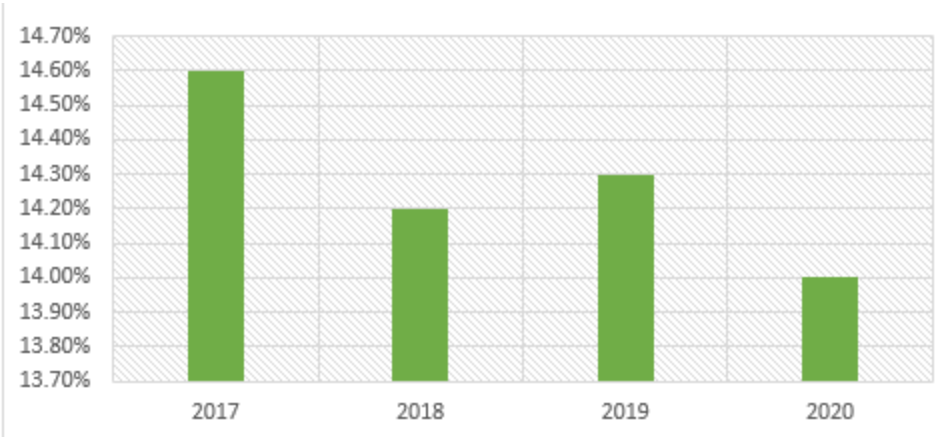


*Figure 1: UEM Engineering female students*

UEM's annual reports consistently show that, although in the STEM area, engineering is the most sought after, female enrolment remains unimpressive (UEM_GAPQEI, 2021). This has led the researcher to consider what might be the lived experiences of the women within the engineering faculty that could possibly be causing negative perceptions, or at the very least, not positive feedback, among aspirant female engineering students. *Where are the women who attend engineering courses? Why aren't their voices heard?*

Historically, women have been less visible in STEM education. They may feel stifled in a male-dominated environment (Madara & Cherotich, 2016). Female students often feel scrutinised by male peers, who expect them to fail (Madara & Cherotich, 2016). It is also likely to find that facilities in STEM do not meet female students' demands. Chou (2014) found that a three-floor industrial school building had only one bathroom for female students.

Throughout human history, technology has enabled opportunities and inclusivity. A person's physical weakness may prevent them from being able to carry an object exceedingly heavy, as opposed to someone physically stronger. But, for example, a lever system can allow the physically weaker person to lift heavy objects easily, giving this person the same opportunities as a stronger person to lift weight. Méndez et al. (2023) suggest technology can drive inclusive education approaches. For instance, Khan (2018) found that female lecturers in Pakistan felt online technologies allowed their voices to be heard, despite gender biases discouraging in-person engagement. This study sought to contribute to the discussion on the under-representation and inclusion of women in the STEM field education at UEM. Using a qualitative approach, it explored whether technology in the engineering classroom at UEM could have an enabling and inclusive effect, providing a potential mechanism for women to participate equally in learning.

## 1.4. Theoretical Framework

To explore the intricacies of social justice within STEM fields for female students, and to examine how technology might play a role in alleviating social injustices, Nancy Fraser's theory of participatory parity was used as a guiding framework (Fraser, 2005; 2009). This study sought to understand the economic, cultural, and political dimensions of injustice that female students face, and how educational technologies can be leveraged to promote equitable participation and inclusion in STEM education. Fraser's theory was chosen because it provides an approach to analysing social justice, emphasising the need for parity of participation across all social domains. This framework is particularly valuable for addressing the multifaceted barriers to inclusion in STEM, ensuring that interventions are not only addressing surface-level issues but also challenging deeper structural inequalities.

## 1.5. Main Research Question

How can educational technologies be used to create more inclusive learning environments in engineering classes so that female students can participate as equal peers and have their voices heard?

### 1.5.1. Research Sub-questions

- What social injustices are identified (in and outside of the classroom) in the graduate engineering courses at Eduardo Mondlane University?
- In what ways can educational technology be employed to promote equitable access to resources and opportunities for female engineering students (economic dimension)?
- How can educational technology be used to foster an environment where female students' identities and experiences are respected and recognised (cultural dimension)?
- In what ways can educational technology be utilised to enhance a greater representation and visibility of female students in engineering courses in order to address women's underrepresentation (political dimension)?

## 1.6. Methodology

This study employed a qualitative, interpretive approach to explore how educational technologies can enhance inclusivity for female engineering students at UEM. This approach treats reality as a subjective social construct, emphasising personal perceptions and experiences. The data collection involved in-depth, semi-structured interviews using Seidman's three-interview technique to explore participants' life histories, recent experiences, and reflections on their significance, particularly in STEM education. A key element was the use of the Participatory Learning and Action (PLA) method, specifically the "River of Life" technique, where participants created visual timelines of their journeys, highlighting significant life events. This method complemented the use of semi-structured and non-structured interviews, facilitating rich, engaging discussions about social injustices faced as female engineering students. The semi-structured format provided consistency, while the non-structured approach allowed for flexibility and depth. Interviews were conducted face-to-face or remotely, recorded, and transcribed in Portuguese and then thematically analysed with NVivo software.

### 1.6.1. Selection of Participants

Participants were selected through purposive sampling, targeting female engineering students in their third year or above to ensure that they were well-acquainted with the educational environment. The recruitment strategy was initially planned to involve teachers but was later adjusted to collaborate with course directors, enhancing effectiveness. An information session communicated the research objectives, leading to the recruitment of six participants who provided informed consent, ensuring a manageable group size while maintaining anonymity and research integrity.

## 1.7. Study Significance

The study is significant as it addresses the critical issue of social justice in STEM education through the lens of women's inclusivity. By illustrating the potential of EdTech as an enabling factor, the research aims to enhance the participation and visibility of women in STEM fields, fostering a more equitable educational environment. The insights gained could lead to practical interventions that promote social justice, allowing female students to engage more fully and equally in their educational pursuits. This research contributes to the broader discourse on gender in STEM and could influence policy and educational practices at UEM and beyond, advocating for systemic changes that support inclusivity and diversity in engineering education.

## 1.8. Chapters Overview

This section provides a brief summary of each of the chapters.

Chapter 1: Introduction- Introduced the issue of gender disparity in STEM at UEM and outlined the research questions, focusing on the role of EdTech in supporting female inclusion in engineering.

Chapter 2: Literature Review- Examines the barriers women face in STEM and discusses the potential of EdTech to foster equality, leveraging Fraser’s theory of "Participatory Parity".

Chapter 3: Methodology- Describes the qualitative methodology, participant selection, and data analysis used to explore the impact of EdTech on female STEM education.

Chapter 4: Findings- Presents findings from interviews with female STEM students, exploring their experiences with EdTech and its influence on their educational journey.

Chapter 5: Discussion- Links the findings to existing literature, discussing how EdTech can address issues of access, identity, and participation for women in STEM.

Chapter 6: Conclusion- Summarises key findings, discusses theoretical and practical implications, and proposes future research directions on technology's role in promoting female participation in STEM.

## 1.9. Conclusion

In this chapter, the underrepresentation of women in STEM, particularly in the Faculty of Engineering at UEM, has been presented as a critical issue that hinders gender equity in education. By highlighting the role of educational technologies, this chapter set the foundation for exploring how these tools can be harnessed to create more inclusive and supportive learning environments for female students. The discussion introduced the theoretical framework of participatory parity, guiding the inquiry into social injustices within STEM fields and the potential for EdTech to mitigate these disparities. Through qualitative research and empirical data, this study aims to provide valuable insights into how technology can empower women in STEM, ensuring their participation as equal peers. The following chapters will build on this introduction by examining the literature, presenting the research methodology, and exploring the findings and discussions that will address the core research questions.

# 2. Chapter 2: Literature Review

## 2.1. Introduction

The pursuit of gender equity in STEM fields is a critical challenge globally, with women significantly underrepresented, especially in areas such as engineering and computer sciences. This disparity is not just a matter of social justice but also impacts the potential for innovation and diversity of thought in these crucial fields. This chapter aims to explore the barriers and opportunities for women in STEM, with a particular focus on the role of EdTech in bridging the gap.

## 2.2. The Underrepresentation of Women in STEM Fields

Over the past several decades, scholars have extensively discussed the persistent underrepresentation of women in STEM fields (Casad et al., 2020; Hoyer, 2024; Kahn & Ginther, 2017; Owuondo, 2023). This issue has been recognised globally as a critical gap in both education and industry, affecting diversity and innovation. Numerous studies have highlighted that women are not only pointedly outnumbered in STEM professions but also face substantial barriers that deter their progress in these fields. For instance, a study by Kahn and Ginther (2017) illustrates that systemic biases and stereotypes continue to undermine women's achievements and presence in STEM. These challenges are not just about numbers, they reflect a deeper societal issue where women's contributions are undervalued, affecting their participation and advancement. The underrepresentation of women in STEM is not only a loss for the individuals affected but also for the field itself, which misses out on the rich perspectives and innovation that greater diversity could bring.

Scholars typically define underrepresentation in STEM through multiple dimensions, including numerical scarcity (Kahn & Ginther, 2017) lack of access to opportunities and limited visibility in leadership roles (Samulewicz et al., 2012). Specifically, underrepresentation often begins with numerical discrepancies, where women are quantitatively fewer in STEM fields. However, another critical aspect is contextual in terms of representational power, as noted by authors like Hoyer (2024). This research aligns with the definition that emphasises the contextual aspect, particularly the lack of representational power, which is deemed (Magliano et al., 2020) more critical for addressing the systemic issues within STEM. According to Hoyer (2024), representational power not only refers to the presence in numbers but also to the influence and decision-making capacity women hold in these fields. This perspective is vital for understanding the full scope of underrepresentation and devising more effective strategies to combat it.

Gender stereotypes, expectations, and bias in STEM fields have been identified as significant barriers that contribute to the persistent underrepresentation and career disparities experienced by women (Owuondo, 2023; Sajid et al., 2020). These elements shape the educational and professional landscapes, influencing both perceptions and opportunities for women in STEM. Research highlights that gender stereotypes start affecting individuals from a very young age. For example, studies indicate that, as early as childhood, stereotypes about gender-specific abilities in STEM begin to form, potentially steering girls away from these fields (Owuondo, 2023). These stereotypes evolve through adolescence and are often reinforced by educational settings and societal expectations, which further perpetuate the notion that STEM fields are not suitable for females.

In the professional realm, gender stereotypes and implicit biases significantly affect recruitment, retention, and advancement within STEM fields. Eaton et al. (2020) note that faculty perceptions of post-doctoral candidates in STEM are influenced by intersecting stereotypes about gender and race, which can hinder the career progression of women. Recruiters often harbour biases that affect their outreach to female candidates in tech, requiring stronger signals of competency from women than men before initiating the contact (Layne, 2023).

In the Global South, the representation of women in STEM fields remains a concern, with distinct barriers that differ from those faced in more developed regions. Lappe et al. (2021) examine the specific obstacles encountered by women in STEM in Mexico, highlighting the importance of addressing local cultural norms and providing role models to inspire future generations. Similarly, initiatives in Brazil, such as the Programa Mulher e Ciência by CNPq, emphasise the necessity of public policies that support women's participation in STEM to reduce gender segregation (Tonini & de Araújo, 2019).

Even so, in sub-Saharan Africa, the representation of women in STEM fields showcases specific regional challenges and ongoing efforts to foster inclusion. Studies from this region emphasise the need for targeted interventions to reduce gender disparities. For instance, the African Research Academies for Women (ARA-W) summer research programme is a significant initiative designed to address the underrepresentation of women in STEM by providing fellowship opportunities and mentored training in prestigious academic and research institutions (Commodore-Mensah et al., 2020)). This initiative is an example of efforts across the continent to empower women through education and to pave the way for equitable participation in STEM fields, thus ensuring that women can contribute effectively to scientific and technological advancements in sub-Saharan Africa.

These regional studies emphasise that, while progress has been made, much work remains to be done. Efforts to empower women in STEM must not only increase their numerical representation but also enhance their qualitative involvement, ensuring they have equal opportunities to influence and lead within their fields. The work by Stewart (2021) on women

STEM leaders using their voices to shape the world through science provides a powerful example of how women are overcoming these challenges and paving the way for future generations in the Global South and beyond.

In exploring the distinction between qualitative and numerical factors of underrepresentation in STEM fields, it becomes clear that both scopes play a crucial role in shaping the experiences and retention of underrepresented groups. Numerical factors often focus on statistical representations such as enrolment numbers and graduation rates, which reveal the disparity but do not provide deeper insights into the underlying causes. On the other hand, qualitative factors delve into the lived experiences, perceptions, and feelings of individuals within these fields, offering a more nuanced understanding of the barriers and challenges they face, which is the aim of this research. For example, research by Kricorian et al. (2020) highlights the significance of mentorship experiences, pointing out that underrepresented students often prefer mentors who match their gender and ethnicity, underlining the impact of role models in fostering a sense of belonging and encouragement in STEM fields. Additionally, factors, such as family support, growth mindset, and perceptions of belonging, are critical qualitative aspects that influence students' decisions to pursue and persist in STEM careers (Sajid et al., 2020). These visions suggest that addressing underrepresentation in STEM requires a comprehensive approach that includes both numerical measures to track progress and qualitative assessments to understand and mitigate the barriers to full participation. Such an approach ensures that interventions are not only effective but also culturally and contextually relevant.

The lack of diversity in STEM fields has notable consequences that extend beyond the immediate environment to impact broader societal and technological developments. Research has consistently shown that diversity is crucial for fostering innovation, as it brings varied perspectives that are essential for creativity and complex problem-solving, which is critical in science and technology. For instance, Cyr et al. (2021) discuss how gender stereotypes aggravate social exclusion in STEM workplaces, negatively affecting women's social fit and engagement, and ultimately, their career success in these fields. Furthermore, the persistent underrepresentation of women and other minorities in academic leadership roles not only impedes progress towards gender equality but also reinforces stereotypes, discouraging these groups from pursuing leadership positions (Hoyer, 2024). This kind of environment can lead to a negative and hostile climate, where increased rates of gender harassment hinder the ability of women to work and learn effectively in STEM (Rincón & George-Jackson, 2016).

Addressing the lack of diversity is not merely a matter of filling numerical quotas but is essential for the long-term health and productivity of STEM fields. This includes fostering environments that are welcoming to all, thereby enhancing the collective ability to tackle complex global challenges more effectively.

The impact of diversity, or the lack thereof, on innovation and problem-solving, particularly in the STEM fields, is vital. Diversity in thought and background fosters a broader range of

viewpoints and enhances the potential for innovative solutions that cater to a wider segment of society. This is key in STEM, where solutions are often intended for societal benefit. However, the underrepresentation of women in these areas can lead to oversight of their unique needs and preferences. A pertinent illustration of such oversight is the development of the first generation of car airbags. Predominantly designed by male engineers, these airbags were tailored primarily for adult males, neglecting variations in physique and safety requirements for women and children. This lack of inclusive design consideration resulted in preventable fatalities among these groups (Margolis & Fisher, 2002), highlighting the critical need for diverse perspectives in all stages of design and engineering.

Another aspect that should be considered is the importance of women's financial health. The economic empowerment of women through STEM careers is a vital pathway to achieving greater societal equality and stimulating economic growth. Studies have demonstrated that women in STEM jobs earn significantly more than their counterparts in non-STEM fields, with a reported wage premium of 33%, which highlights the potential of these careers to enhance the economic status of women (Beede et al., 2011). By mentoring and inspiring high school girls through connections with successful women in STEM fields, initiatives like the Young Women in Science and Engineering (YWISE) foster a sense of autonomy, self-efficacy, and identity, which psychological empowerment is crucial for nurturing confidence and sense of belonging (Cole, 2014).

## 2.3. Importance of Inclusion in STEM Education

Given the challenges previously highlighted, inclusion must be central to strategies aimed at reducing underrepresentation in STEM fields. Persistent disparities in STEM reflect not only access issues but also the need for inclusive practices addressing the diverse needs of underrepresented groups. Effective inclusion transcends numerical representation, encompassing environments where all individuals, regardless of race, gender, and background, feel valued and have equal voices and opportunities to thrive.

Much of the research on educational inclusion primarily focuses on disabilities, an essential and well-documented area. Systematic literature reviews reveal the impacts of various inclusion strategies on students with disabilities (Hernández-Saca et al., 2023; Rademaker et al., 2020). However, this focus often overlooks other crucial diversity and inclusion aspects. Since inclusive education is closely tied to disability issues (Guðjónsdóttir & Óskarsdóttir, 2016), other barriers to student engagement may be neglected (Musara et al., 2020). In STEM education, women are notably underrepresented, and the prevalent focus on disabilities might neglect their specific inclusion needs. While addressing disabilities is crucial, it is imperative to also address women's needs in STEM comprehensively, fostering a truly diverse and equitable academic environment.

The concept of inclusion in education and professional contexts encompasses a wide range of interpretations, particularly in enhancing diversity and equality. Educational inclusion often follows frameworks like systems theory, suggesting a multidimensional approach to how factors interact within educational ecosystems (Qvortrup & Qvortrup, 2018). This theory aids in operationalising inclusion by identifying key dimensions like accessibility, participation, and support, crucial for integrating diverse student populations, including those underrepresented in fields such as STEM. The term 'inclusion' in education is made complex by different global interpretations and implementation challenges, as noted in the Salamanca Statement. This document emphasises accommodating all children, regardless of their various conditions (Magnússon, 2019). Such broad definitions highlight the challenge of implementing inclusive practices that ensure not just physical but full academic and social integration of all students. Comprehensive inclusive education requires understanding the barriers affecting various student groups.

In this study, inclusion in STEM for women is redefined to address not just their numbers but also the qualitative aspects of their experiences and participation. Inclusion is about creating an environment where women can thrive as equal participants, breaking down social, cognitive, and cultural barriers that limit their engagement and advancement (Casad et al., 2020; Owuondo, 2023). This includes identifying elements that facilitate networking, confidence, and interest in STEM, fostering a supportive community that encourages entry and retention (Casad et al., 2020). Moreover, inclusion here is viewed through the lens of social justice, considering how women perceive their roles and acceptance in STEM. Effective inclusion practices mitigate stereotype threats and enhance a sense of belonging, making STEM fields more accessible and appealing to diverse women (Kim et al., 2018).

In Mozambique, research on women in STEM reveals a significant gap in understanding the barriers they face in this field. While there is some awareness of their underrepresentation, detailed knowledge about the specific economic, environmental, sociocultural, and personal factors is lacking (Commodore-Mensah et al., 2020). Much of the literature focuses on quantitative aspects like enrolment statistics, neglecting the qualitative experiences of women already on the STEM pathway, whether academically or professionally (Uamusse et al., 2020). This oversight may ignore the unique challenges faced by these women. Additionally, the lack of role models and mentors is a noted barrier in Mozambique, similar to wider African contexts (Dzisi et al., 2022). These research gaps stress the need for studies that address both numerical and broader socio-cultural factors, to develop effective interventions supporting women in STEM.

Creating a stimulating and competitive environment for women already in STEM requires strategic interventions to tackle systemic and localised challenges. Emphasising the need to provide more female role models and mentors is critical for increasing women's participation in STEM jobs and academia (Casad et al., 2020; Owuondo, 2023). Addressing educational and career development barriers through programmes promoting equal opportunities in scientific

knowledge and professional practice is vital. Studies emphasise the importance of interventions that promote gender equality and improve access to educational resources and professional environments supportive of women's STEM success. Transforming negative societal attitudes towards women in business and science can nurture a more competitive and empowering environment, enhancing women's contributions to STEM in Mozambique.

## 2.4. Theoretical Framework: Nancy Fraser's Theory of Participatory Parity

Inclusion is an aspect of social justice (Musara et al., 2020). This study made use of Nancy Fraser's theory of participatory parity (Fraser, 2005, 2009) to guide the investigation of social justice for female students in STEM education at UEM. Nancy Fraser is a critical feminist, political, and social theorist (Gredley, 2022) who established the three-dimensional theory of participatory parity (Fraser, 2005, p.73), which is the idea that everyone should be able to take part as peers and equals in all social areas (Fraser, 2009). Fraser's participatory parity theory has attracted the attention of many academic researchers, and it is seen as a thorough and valuable conceptual framework for exploring and assessing educational injustices (Gredley, 2022).

The social justice framework of Fraser has been used for analysing and addressing social injustices (Farrow et al., 2021). The conceptual dimensions of Fraser's social justice framework (Fraser, 2005, 2009) were applied to recognise instances of injustice toward minorities in the engineering learning environment at UEM, particularly women students. Furthermore, the same theoretical underpinning was employed to understand whether EdTech could be used in engineering classrooms, which might contribute to pursuing participatory parity regarding women's inclusion in this learning environment. Fraser (2009) argues that social justice can be reached if participatory parity is taken into account, and adds that participatory parity includes establishing opportunities for authentic democratic discourse and a decision-making process in which everyone's opinions are heard and appreciated equally as shown below in Fraser's own voice:

> "In my view, the most general meaning of justice is parity of participation. According to this radical-democratic interpretation of the principle of equal moral worth, justice requires social arrangements that permit all to participate as peers in social life. Overcoming injustice means dismantling institutionalized obstacles that prevent some people from participating on a par with others, as full partners in social interaction" (Fraser, 2009, p.16).

For Fraser (2009), participatory parity can be achieved when all three dimensions, namely, economic, cultural and political, are addressed (Fig. 2), and none of them alone is enough to accomplish social justice. Fraser highlights that these three dimensions overlap each other and are interconnected, but, neither of them could be used in place of the other.

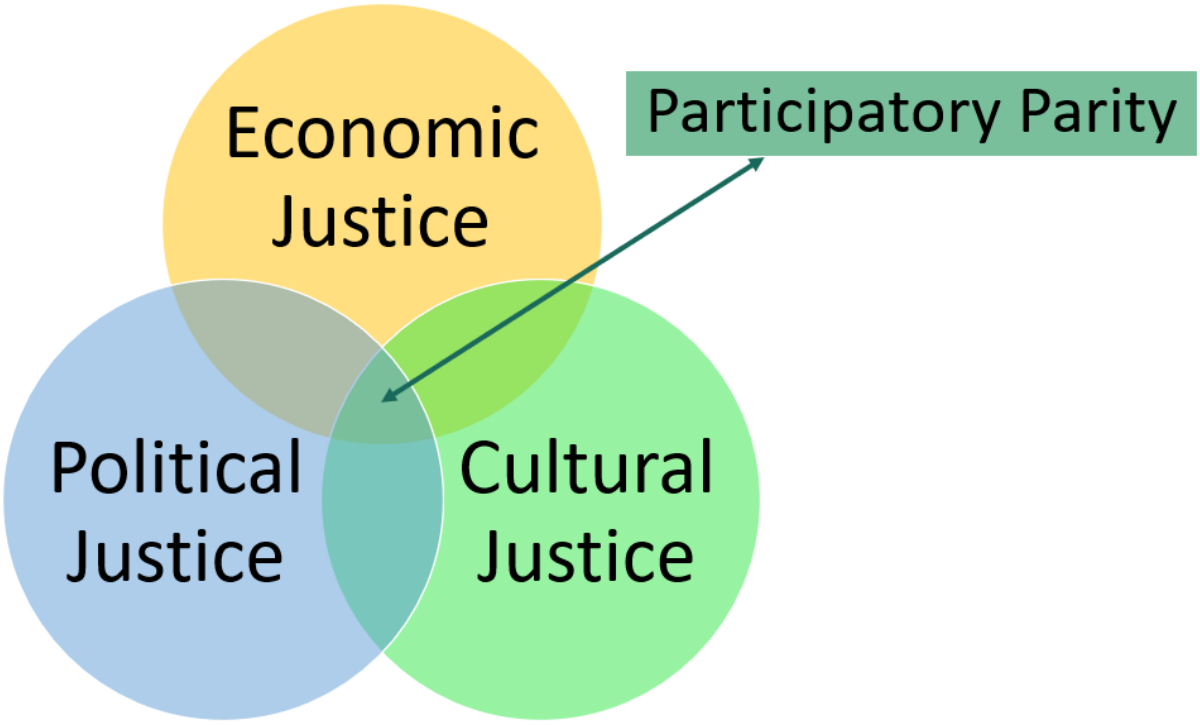


*Figure 2:Based on Fraser's Social Justice Framework (Fraser, 2009)*

Fraser's theory delineates three significant impediments to addressing participatory parity: economic injustice, cultural injustice, and political injustice. Fraser (2005) defined economic injustice as a disparity in resource allocations, and named this injustice 'maldistribution'. Fraser recognises that economic inequality is a fundamental issue of social injustice, since "people can be impeded from full participation by economic structures that deny them the resources they need in order to interact with others as peers'' (Fraser 2005, p. 73). Economic redistribution is required to solve this issue (Bozalek et al., 2020). For instance, Bosch and Pondayi (2022), when analysing conditions for research grants and their effects on women's (dis)engagement for applications, noticed that the formulation of research grant opportunities is gender neutral. Bosch and Pondayi (2022) warned that, at first sight, the research grant being gender neutral might seem like a good thing, but gender neutrality can be nuanced, because, if we look deeply, the men's versus women's study cycles are different because women may for example, have to include motherhood into their cycle, so the poor distribution of resources may be hidden in a positive attempt to address the issue.

According to Fraser (2005), cultural injustice is rooted in the 'misrecognition' of distinct identities, which is linked to the issue of cultural dominance and marginalisation of minority groups. Publicly recognising identities and individual differences is an important element in achieving social justice (Bozalek et al., 2020) because "people can also be prevented from interacting on terms of parity by institutionalised hierarchies of cultural value that deny them

the requisite standing" (Fraser 2005, p. 73). Cultural injustice can, for instance, happen when the behaviour of a traditionally dominant group marginalises the minority groups, and being disregarded or misrecognised impacts learners' feelings of belonging and their ability to adapt to the learning environment (Dykes, 2018). In a study conducted in Tanzania on the perception of female students regarding their integration into courses related to ICT in HE (Innocent & Kipene, 2022), the respondents indicated the issue of gender stereotypes is a challenge for them because they feel that society's mentality presumes that technology is restricted to men. In their study of parental gender bias in the allocation of resources within the family, Begum et al. (2022) found that biased parents give resources to their children in a discriminatory manner: if the parents are biased toward boys, they will allocate more resources to the boy to the detriment of the girls. However, if the parents are biased towards the girl, they give her the same benefit the boy already has, which means that boys have their place granted in either case.

When authority is abused, leading to the exclusion of certain groups from the opportunity to engage on an equal footing the result is misrepresentation and political injustice (Fraser, 2009). Only when all members of society have access to practices that encourage expressive representation will political justice be considered to have been completely realised, because the political dimension is "considered a prerequisite for addressing issues of redistribution and recognition" (Brownlee et al., 2012, p. 20). The political dimension "specifies the reach of those other dimensions: it tells us who is included in, and who is excluded from, the circle of those entitled to a just distribution and reciprocal recognition" (Fraser, 2009). For example, in HE, representation could assist students' sense of belonging (Gredley, 2022), Dykes (2018) says that even learners in minority groups need to be able to join the Student Representative Council to have a voice regarding their concerns. Innocent and Kipene (2022) argued in their research that the female students who took part said that the absence of female mentors and role models is discouraging their participation in ICT courses in HE. Hussain (2016), added that only if women are properly represented in decision-making bodies can their voices and needs be heard.

Each of the three dimensions of Fraser's framework can be approached from either an affirmative or transformative perspective for social justice. It is important to note that these two perspectives are not concurrent; they operate at different levels of goals. The transformative perspective represents a higher level and is the ultimate, desirable goal. The affirmative perspective seeks justice within a certain defined structure; it tolerates the social structures that have established the practices that must be changed (Fraser, 2005). It could implement redistribution and recognition, but it does not change the structures that led to inequality initially (Luckett & Shay, 2020). A transformative perspective, on the other hand, questions the underlying structure that provokes injustice (Fraser, 2005). If those who are affected by a social policy or practice have greater access to the process of setting the structure, new spaces will extend in which the affected voices can participate in support of better just social practices (Luckett & Shay, 2020).

The concepts of redistribution, recognition, and representation of Fraser's framework have been applied in order to analyse how to address social injustices (Cox et al., 2022; Dykes, 2018; Musara et al., 2020). Cox et al. (2022) applied Fraser's social justice framework in relation to digital open textbooks and open education practices. They critically examined the UCT context to investigate injustice in terms of economic, cultural, and political dimensions of social justice and analysed the magnitude to which the production of digital open textbooks and open education practices in the classroom enhance social justice through parity of participation. Cox et al. (2022) suggest that digital open textbooks and open education practices offer a potential way of addressing economic, cultural, and political injustices and could perform a valuable role in facilitating education strategies for social justice. In their study, Musara et al. (2020) presented inclusion as social justice, and applying Fraser's social justice framework, they evaluated inclusion analytically in the South African context. They demonstrated how this meaningful framework of justice allows for the understanding of educational inequalities and inequities and how to employ this framework to create valuable approaches in the area of inclusion that support students with different needs. Dykes (2018) applied Fraser's theory of participatory parity to investigate social work learners' experiences in order to identify aspects related to the facilitating and restricting elements in enhancing these students' participation and commitment in the context of a particular university.

This research also aimed to determine whether participatory parity could be pursued in the STEM learning environment by applying each of the three dimensions proposed by Fraser (2005, 2009) as a theoretical framework for the analytical discussion of results in this study. The same framework was used to understand if the use of educational technologies in the teaching and learning process in engineering learning environments could be applied as an affirmative or transformative remedy to promote women students' participation equally and equitably in learning activities.

## 2.5. Women in STEM Education: Barriers to Participation

Gender stereotypes and biases persistently hinder women's participation and advancement in STEM fields (Casad et al., 2020; Kahn & Ginther, 2017; Owuondo, 2023; Sajid et al., 2020). These stereotypes manifest in several ways, including physical robustness stereotypes, assumptions about maternity, and inherent biases that can meaningfully impact women's career trajectories and experiences in these areas. Research has demonstrated that societal biases often destabilise women's scientific abilities. According to Hill et al. (2010), negative stereotypes about their physical and cognitive abilities often discourage women from pursuing STEM careers traditionally viewed as more demanding.

The challenges of maternity, such as the need for maternity leave and flexible work arrangements, are not always adequately supported, further exacerbating the difficulties women face in STEM fields (Hill et al., 2010; Howe-Walsh et al., 2016). These biases, coupled with

societal expectations regarding maternity, can lead to discriminatory practices in the workplace, which impact women's professional growth and satisfaction (Hill et al., 2010; Howe-Walsh et al., 2016)). Such biases discourage many potential female STEM professionals, contributing to the gender gap in these critical areas. Not only are these practices detrimental to individual women in their career trajectories, but they also hinder the broader STEM community, which thrives on diverse perspectives to drive innovation and problem-solving.

The challenge of STEM fields access for women involves both the absence of female role models and support structures, such as family support, that enable women to sustain careers, particularly through maternity. Studies emphasise the critical role of female role models in inspiring and retaining women in STEM (Greider et al., 2019; Sajid et al., 2020). Research shows that the visibility and success of women in STEM significantly influence younger women's decisions to enter and persist in these fields, demonstrating the importance of representation (Innocent & Kipene, 2022). Systemic support, including mentorship programmes and networking groups, is crucial for increasing women's participation and retention in STEM (Casad et al., 2020; Saj et al., 2018). These elements provide practical assistance and foster a more inclusive and supportive environment, encouraging more women to enter and remain in these fields.

Moreover, policies that support work-life balance, such as maternity leave policies directly impact women's ability to balance career and family life, which is crucial for their retention in STEM careers (Howe-Walsh et al., 2016). Effective maternity leave policies that support women during and after pregnancy can help mitigate the dropout rates often observed during these critical life stages. Policies that are supportive rather than punitive can lead to better job satisfaction, greater work-life balance, and a more robust representation of women in STEM fields over time (Greider et al., 2019).

Financial investment in STEM education is demanding in terms of time and material resources needed, which is another important factor that is often skewed by cultural biases (Greider et al., 2019), particularly within the patriarchal structures prevalent in developing countries. These biases often shape educational investments from an early age, typically favouring boys (Begum et al., 2022), thus marginalising girls' opportunities in crucial STEM fields. This bias extends into the realm of STEM education, where substantial investments are necessary for developing the infrastructure, curriculum, and support systems conducive to scientific inquiry and innovation. However, these investments frequently overlook the specific needs and challenges faced by women in STEM fields. Studies show that financial grants and scholarships targeted at minorities like women can play a pivotal role in balancing this inequity (Enriquez et al., 2014).

Research indicates that resource allocation, including scholarships and grants, often favours males, reflecting deep-rooted cultural norms that prioritise men’s education. This disparity not only affects the immediate educational opportunities for women but also their long-term career

prospects in STEM. The lack of financial support for women in STEM perpetuates a cycle of underrepresentation, making it challenging for future generations of women to view these careers as accessible and viable options. Initiatives providing funding for girls in STEM not only help alleviate financial barriers but also serve as an essential tool against the cultural biases that often limit women's participation in these fields (Greider et al., 2019; Kong et al., 2020). Moreover, environments that support women's economic empowerment through STEM can lead to broader societal benefits, including increased gender equality and economic development (Kong et al., 2020).

## 2.6. Technology as an Enabling Factor for Inclusion

Historically, technology has often been seen as a force of marginalisation due to the disruptions it causes upon its introduction; an overly mentioned example is the effects of the Industrial Revolution. However, ICTs, in particular, have a more positive outlook when looking at how it offers a viable platform for amplifying marginalised voices and democratising access to power (Ackermann et al., 2009; O'Byrne, 2019; Sharma, 2023). Technologies, such as radio, television, and especially, more recently, the internet with its interactive spaces, have significantly contributed to broader public engagement and empowerment (O'Byrne, 2019). The network society facilitated by digital technologies has transformed the way information is disseminated, making it more accessible and thus empowering individuals by levelling informational disparities. The advent of the internet has transformed access to information and participation in public discourse, allowing diverse groups to have a voice and influence in global conversations. This democratisation has been particularly impactful in allowing marginalised communities, including women in STEM, to connect, share experiences, and advocate for their rights and inclusion in broader societal structures.

Technology plays a transformative role, particularly through the availability and customisation of free, curated online content, and has the potential to create highly inclusive educational environments. These resources, often referred to as open educational resources (OER), provide the affordability and accessibility necessary to meet the specific needs of students, taking into account local contexts and realities. For example, OER allow educators to adapt materials to suit diverse learning styles and needs, which is crucial in regions where educational resources are limited or not sufficiently diversified (Cox & Trotter, 2017; UNESCO, 2019). OER not only reduce the cost of educational materials but also enhance the quality and availability of learning opportunities globally (UNESCO, 2019).

Additionally, mobile education technologies offer significant affordances for inclusion by providing flexible and accessible learning opportunities. These technologies enable students to access learning materials anytime and anywhere, which is particularly beneficial for learners who may face geographical, physical, or socioeconomic barriers. Mobile education supports a range of educational activities from primary to HE, facilitating continuous learning outside the

traditional classroom setting and empowering students through personalised educational experiences (Bauer et al., 2020). These platforms are particularly effective in bridging educational gaps for learners, offering flexible and user-centred learning experiences that accommodate various learning styles and needs (Ossiannilsson, 2018).

Studies show technology's potential to bridge educational gaps and promote inclusion, especially among underprivileged learners, enhancing access and equity. Warschauer (2004) found that effective integration of technology in education can provide lower-income students with resources and opportunities similar to their affluent peers. Moreover, Mavengere et al. (2022) explored how technology reduces educational inequalities in underserved regions, finding that digital tools narrow both the digital and educational divide by providing quality resources and enabling personalised learning experiences. This integration mitigates socioeconomic disparities by offering equitable access to quality education. Additionally, interactive and adaptive digital platforms tailor content to diverse student needs, fostering a more engaging learning environment (Bauer et al., 2020)). This approach supports academic achievement and enhances digital literacy, crucial for participation in contemporary society.

Technology also supports the inclusion of students with specific educational needs, as demonstrated by various educational technologies that facilitate access to learning for students with disabilities. This approach not only enhances educational participation but also supports the broader goals of social inclusion by ensuring that all learners, regardless of their individual challenges, can benefit from tailored educational interventions (Kaur & Kaur, 2021).

Using technology for inclusion can effectively achieve participatory parity. When applied consciously and collaboratively, EdTech is accessible, customisable, and interactive, key traits inherent in ICTs. These ensure all students, regardless of socio-economic background or location, can access high-quality resources and engage equally in learning. Fraser (2005, 2009) emphasises that achieving participatory parity involves removing institutional obstacles to equal participation, which is critical in education. This notion is embodied in technology creating inclusive practices that accommodate diverse needs and backgrounds (Kaur & Kaur, 2021; Ossiannilsson, 2018). Educational technologies like OER and mobile learning apps exemplify this by providing adaptable, inclusive platforms catering to diverse learning needs and preferences. This approach aligns with inclusive education goals, transforming access and engagement through technology and fostering a more equitable educational landscape.

In the realm of digital education, the ability of technology to customise and interact with educational materials is crucial for addressing the specific learning needs of diverse student populations. This technological adaptability ensures that all students can engage with educational content in ways that respect their individual contexts and capabilities. This promotes a truly inclusive learning environment that reflects Fraser's concept of participatory parity, where all learners have the opportunity to participate on an equal footing, enhancing both educational outcomes and equity.

While educational technologies are increasingly recognised for their potential to democratise access to education for underprivileged K-12 girls, especially in African countries, there is a gap in recognising these technologies as inclusive for women already in STEM education. Initiatives like Girls4STEM engage female students from an early age in STEM through interactive technologies (Benavent et al., 2020), but focus on initial engagement rather than ongoing support for women already in STEM. This oversight can lead to a lack of sustained interest and engagement among women, who may face ongoing barriers despite their initial introduction to STEM fields. Furthermore, projects enhancing women's interest in STEM through technology often do not provide continued support during advanced educational and professional phases. EdTech has been shown to empower women in STEM by providing resources and networks to bridge the gender gap, but more is needed to support women throughout their entire educational and career journey.

## 2.7. Conclusion

This chapter has explored the persistent issue of the underrepresentation of women in STEM fields, as evidenced by the literature review. While it is encouraging to see a growing number of studies addressing the challenge of attracting women to STEM, it is critical to acknowledge that the scope of existing research often neglects the experiences of those women already engaged in STEM studies. This oversight highlights a gap in our understanding, which this study aimed to address.

This research distinguishes itself by not only examining underrepresentation through traditional quantitative metrics but also by embracing a contextual perspective that brings to light the lived experiences and personal narratives of women in STEM. By focusing on personal stories, this study enriches the conversation around underrepresentation, providing deeper insights into the challenges and triumphs faced by women in these fields.

Moreover, the application of Fraser's participatory parity theory has proven to be a powerful tool for framing issues of social justice in educational settings. By specifically looking at how educational technologies at UEM Engineering Faculty affect participatory parity for women, this study contributes to a broader conversation of social justice as formulated in the main research question in chapter one. It offers insights that could lead to enhanced participatory experiences for women in STEM, thereby improving their academic journey and fostering a more inclusive educational environment.

# 3. Chapter 3: Methodology

## 3.1. Introduction

This chapter details the methodology used to explore how educational technologies can foster more inclusive learning environments in engineering classes, enabling female students to engage equally and express their perspectives. The chapter starts with an examination of the research paradigms, followed by a breakdown of the design, methods, strategy, and approaches. This description clarifies, defends, and discusses the pros and cons of the research context, concepts, tools, and techniques used.

## 3.2. Research Approach

This study employed a qualitative, interpretive approach to examine the role of technology as an enabler in fostering inclusivity in UEM's engineering classrooms, focusing on enhancing female participation in STEM education. The interpretive perspective considers reality a social construct, inherently subjective, mutable, and context-dependent, varying between individuals. This view emphasises that people actively construct their world understanding, which is fluid and changes over time due to different contexts (Cohen et al., 2011).

According to Cohen et al. (2011), interpretive research's core is its qualitative nature, aiming to understand how individuals interpret experiences within specific contexts, revealing the nuances of participant perspectives. Maxwell (2008) highlights the capacity of qualitative inquiry to meet various scholarly goals, particularly in generating insights that reflect real-life experiences, thus enhancing, not just evaluating, methodologies' effectiveness. Maxwell (2008) emphasises qualitative research's ability to fulfil intellectual and practical objectives. Intellectually, it explores how individuals understand their experiences. Practically, it aims to improve, not just evaluate, current practices.

The research explored the lived experiences of female engineering students at UEM, aiming to understand how technology can create a more equitable STEM educational environment. Maxwell (2008) notes that qualitative research can foster a collaborative and empowering environment, enabling data collection that resonates deeply with participants' realities. This study has captured participants' perceptions and experiences with technology in STEM education, and stressed how technological interventions can cultivate an inclusive and supportive learning space for women.

For data collection, a qualitative approach was used with in-depth interviews, following Seidman's (2013) approach that combines life history interviews and focused discussions on the research topic. The researcher applied the three-interview technique, facilitating an

investigation where participants gradually reconstructed their experiences related to the research focus. This method enabled a nuanced exploration of participant experiences.

The three-interview technique gave participants time to reflect on past discussions, making the process transformative. The women noted that they had not previously considered their inclusion in STEM areas, even though they belonged to this environment. This method deepened participant awareness and consideration of the topic. The interviews also explored economic, cultural, and political injustices, using Fraser's social justice framework (Fraser, 2005, 2009), enriching the understanding of the research complexities and thoroughly investigating participants' perspectives and experiences.

### 3.3. Selection of Participants

The research focused on women studying engineering at UEM to understand their experiences. Participant recruitment used purposive sampling (Showkat & Parveen, 2017), selecting participants based on study objectives. A 1-hour information session was organised for third-year or senior women engineering students, ensuring that they were familiar with the department's educational environment. The session explained the research context and goals and invited students to share their perspectives as participants.

Initially, the plan was to access students through teachers, but after discussions, coordinating with course directors was deemed more effective. Thus, course directors helped distribute information sheets and present inclusion criteria among the students. Interested students registered for the session by emailing the researcher. Additionally, course directors nominated two students directly. First-year and second-year students who applied were not included as they did not meet the two-year academic exposure criterion necessary for participation.

The information session, lasting one hour, was held in a faculty room, timed to fit the students' schedules. A PowerPoint presentation outlined the research aims, design, and ethical data handling, including the significance of the consent form. After the presentation, students were invited to join the research and ask questions, providing feedback on the design and objectives. Of the twelve targeted students, seven agreed to participate; five declined due to schedule conflicts or discomfort. Specifically, one among the five students who declined was uncomfortable sharing personal experiences in a research setting, despite anonymity assurances. To preserve anonymity and research integrity, the participant pool was narrowed, excluding two of the seven volunteers at risk of being identifiable as the sole women in their classes. Following a clear discussion about identity protection, they agreed with the decision.

The researcher's own experiences as a student and teacher in engineering heightened her awareness of the students' sense of exclusion. Therefore, the researcher invited an additional student, not previously considered, to join the study, increasing the total participants to six.

These students, aged 20 to 30 were from diverse regions and engineering disciplines, in their fourth or fifth year, which was a divergence from the initial plan to also include third-year students. Participants represented almost every engineering course at UEM, including Computer, Mechanical, Civil, Environmental, Chemical, Electrical, and Electronic Engineering. Due to their minority status, providing a detailed demographic table would compromise their anonymity and risk identifiability.

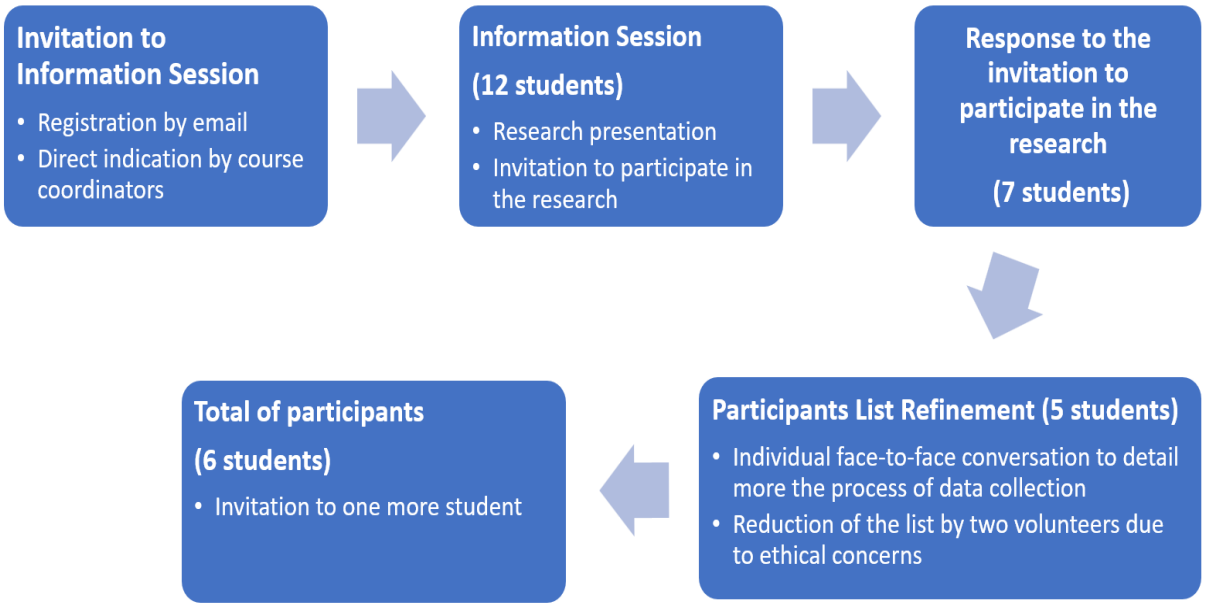


*Figure 3: Participants Selection*

## 3.4. Data Collection

Data collection involved in-depth, semi-structured interviews using Seidman's (2013) three-interview technique. This method allowed for a detailed exploration of the context, helping participants rebuild their experiences over each session. The detailed sequence deepened the researcher's understanding of participants' viewpoints and the complexities of their experiences.

Seidman's (2013) three interviews had distinct objectives: The first interview explored participants' life histories, focusing on their background and early experiences, and their path to STEM education, including any social injustices they faced. The second interview delved into more recent experiences and interactions in their STEM environments, examining social injustices through Fraser's framework and the role of educational technologies in addressing these issues. The third interview encouraged participants to reflect on the significance of their experiences, assess the impact on their current situations, and evaluate the potential of digital education as a transformative solution, particularly in achieving participatory parity.

During interviews, participants shared their stories and experiences using the River of Life technique, semi-structured, and non-structured interviews. Originally, community mapping (Bozalek & Biersteker, 2010) and focus groups were planned but not used, reasons for which are explained later. The River of Life approach, creating visual life event timelines, allowed participants to compellingly depict and share their stories, emphasising their journey to and within engineering. Through individual interviews, participants articulated their opinions and experiences regarding the economic, cultural, and political inequalities they faced as women studying engineering.

This research adapted Seidman's (2013) three-interview method to suit the young participants' needs. Seidman suggested ninety minutes per interview but recommended shorter sessions for younger participants. Considering the participants' limited availability due to their academic and social commitments, each interview was set to last sixty minutes. This duration was pre-determined as Seidman (2013) emphasised, ensuring structured, consistent sessions that met participants' needs. This clear, planned approach helped maintain methodological integrity and effective engagement with each participant. In practice, the second and third interviews fit the sixty-minute framework, while the first often exceeded this duration but remained under the ninety minutes Seidman recommended. This flexibility in interview lengths accommodated participants' backgrounds and response depths, ensuring thorough exploration of their experiences.

Seidman (2013) acknowledges that changes in interview duration and intervals can be necessary to reflect and rebuild participants' life experiences while maintaining a structure. In this study, deviations from the recommended two to three-week interview spacing extended to five weeks due to factors like academic commitments and illness, leading to frequent rescheduling. This adaptation aligns with Seidman's perspective that adjustments are not inherently negative if they facilitate participant reflection.

Seidman (2013) recommends completing all participants' interviews in one set before proceeding to the next. Despite the extended timeline, this was beneficial, the additional time enabled preliminary analysis and development of initial findings, which informed later interviews, as per Seidman's guidelines. It was also observed that participants also showed increased interest in discussing the research subject in later sessions.

Table 1: Interview process

| Interview | Technique of data collection | Length of interviews (average) | Period conducted | Spacing to the next set of interviews (average) |
|---|---|---|---|---|
| First Interview - Life History | River of Life | 75 min | 15 June - 27 July | 5 weeks |
| Second Interview - Experience Details | Semi-structured interview | 60 min | 29 August - 11 September | 5 weeks |
| Third Interview - Reflection on the Meaning | Non-structured interview | 50 min | 20 October – 6 November | |

Interviews were conducted face-to-face or remotely, based on participant preferences, and all sessions were recorded. Participants signed a consent form and received detailed clarifications about their research participation before the interviews. In the initial interviews, participants used the “River of Life”, a PLA method (Bozalek & Biersteker, 2010), conducted face-to-face, primarily on campus, except for one off site due participant preference. The participants were given paper and shown examples of “River of Life” illustrations, then had 20 to 25 minutes to create their own River of Life. Discussions followed, guiding participants from early life to the present, examining each significant event depicted. An example of a participant's “River of Life” is displayed in Fig. 4.

Initially aimed at exploring female engineering students' early life and entry into engineering, the first interview's actual discussions were more fluid. This flexibility allowed exploration beyond the intended scope, including classroom technology use, showcasing the dynamic interview process and topic breadth.

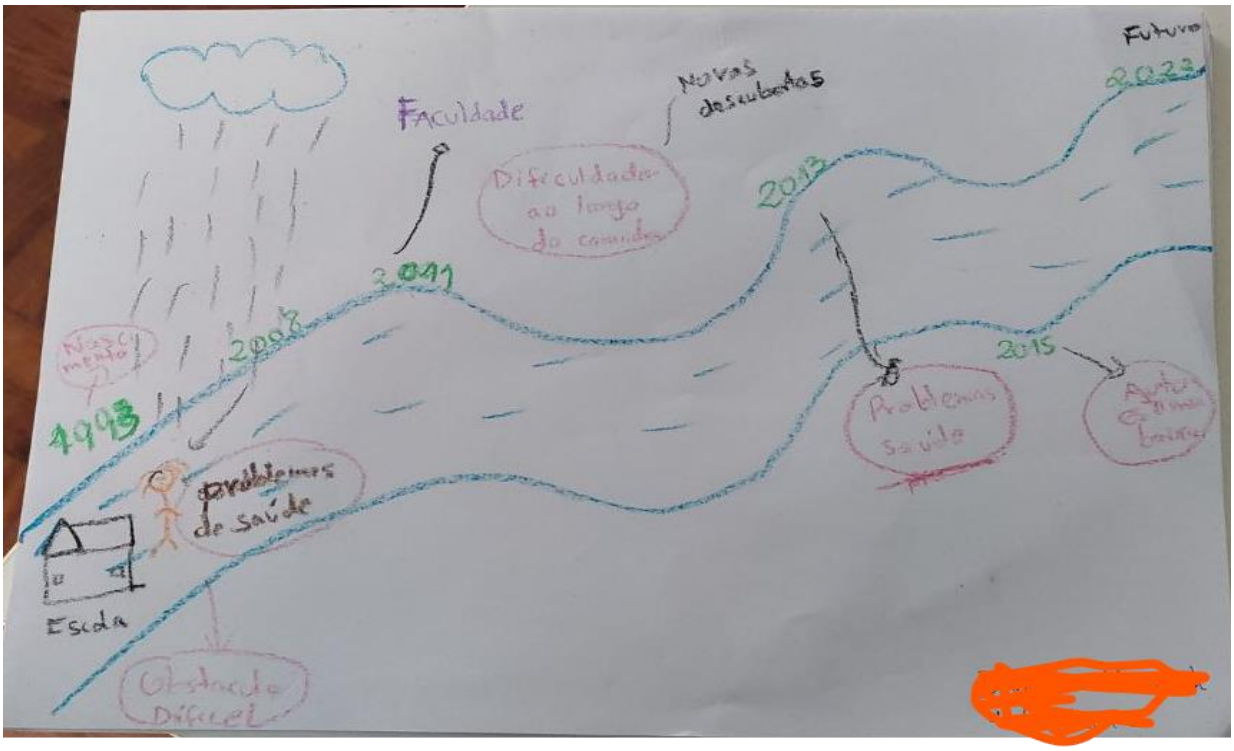


*Figure 4: Participant's River of Life*

To maintain consistency, all interviews using the "River of Life" technique followed a semi-structured questionnaire with thirteen questions (Appendix D), ensuring uniform experiences. The semi-structured format allowed question rephrasing, deepening exploration of experiences depicted in participants' timelines. These adjustments fostered a dynamic, engaging discourse, encouraging freely sharing of experiences and perspectives.

The second set of interviews occurred five weeks after the first, allowing participants to review prior excerpts before the next meeting. Conducted to fit participants' preferences, two interviews were face-to-face and four virtual, all recorded for accuracy. Preliminary analyses of initial interviews and a semi-structured questionnaire (Appendix E) grounded these round's discussions. The focus was on students' current academic experiences, identifying social injustices as defined by Fraser's framework and examining the role of educational technologies in addressing these injustices faced by female students.

Five weeks following the second interviews, the third round allowed participants to review earlier excerpts and findings. All interviews were virtual, matching participant availability. It was hoped that participants could also take part in a focus group to collectively explore the women's perceptions, but because of participants' discomfort, this was adjusted to non-structured individual interviews due to concerns about collective reflection. This change also led to the omission of planned community mapping activities initially designed.

These interviews commenced with the researcher presenting initial findings, followed by participant feedback on these insights and their transformative impact. Insights from this round supported earlier conclusions and offered additional perspectives on student beliefs about technology integration in engineering education, enhancing overall study understanding.

The observation phase was initially planned as the final stage of data collection, aimed to evaluate the Learning Management System (LMS) at UEM, focusing on female student engagement online within the LMS. However, interviews revealed the LMS was predominantly utilised for submitting tasks and searching content, not for active student interaction. This discovery indicated that the LMS did not facilitate the level of student engagement and interaction initially anticipated in the study's design. Consequently, this affected the approach and focus of the observation stage, highlighting the importance of adapting research methods to emerging findings.

## 3.5. Data Analysis

Interview data, including audio recordings and notes, were transcribed and analysed using thematic analysis (Braun & Clarke, 2006). Since the study participants were native Portuguese speakers, interviews were conducted in Portuguese. Audio recordings were initially transcribed in Portuguese for analysis. After this, only the recurring patterns, key insights, and relevant passages were translated into English. Google Translate facilitated initial translations, followed by a detailed human review to correct any errors, ensuring accuracy and clarity in the final manuscript. Data analysis followed that of Braun and Clarke (2006):

- **Phase 1- Become familiar with the data:**
  Becoming familiar with data involved reading and reviewing transcripts to methodically understand the interview data, taking notes on initial impressions.
- **Phase 2- Generate initial codes:**
  Initial codes were generated by systematically organising the data. Coding was based on metadata related to the research topic, aiming to compress vast data into relevant pieces according to research questions under Fraser's framework.
- **Phase 3- Search the preliminary themes:**
  Preliminary themes were searched by analysing and categorising the codes into significant themes, then organised to highlight crucial research topic aspects.
- **Phase 4 - Review themes**
  Reviewing themes involved reassessing and refining the selected themes, grouping relevant data per theme, and verifying their support for the themes to ensure applicability to the entire dataset.

- **Phase 5 - Define themes**
  Defining themes, the final stage, focused on identifying the essence of each theme, exploring connections between sub-themes and the main topic, and determining the interconnection of themes. An overarching theme typically represented the research response.
- **Phase 6 – Write up the report**
  Writing up the report marked the research culmination, featuring an in-depth analysis and the report itself, incorporating data quotes to create a clear, consistent, and logical narrative based on the data's story.

## 3.6. Data Management

The software NVivo was used to support data management and facilitate qualitative analysis, with its specialised functionalities mediating each phase of the analysis process. The images presented here intentionally blur the contents to protect the confidentiality of the raw interview data, focusing instead on showcasing the use of NVivo for coding and data analysis in this research.

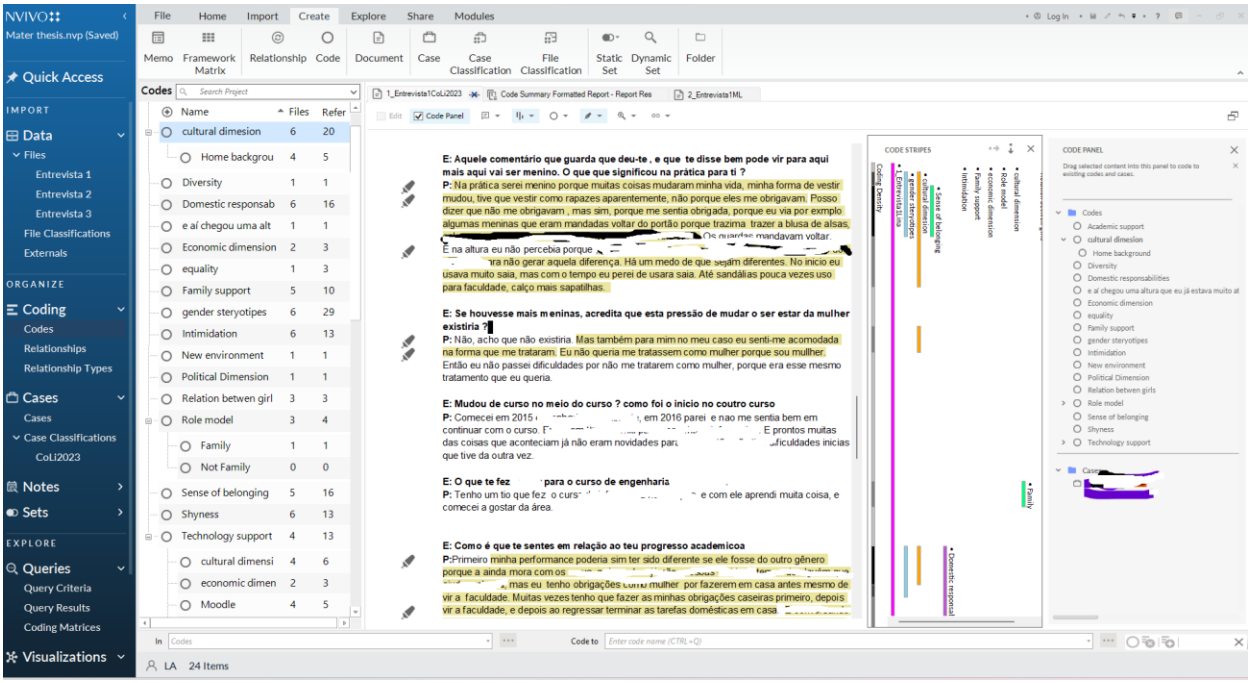


*Figure 5: NVivo Code Panel*

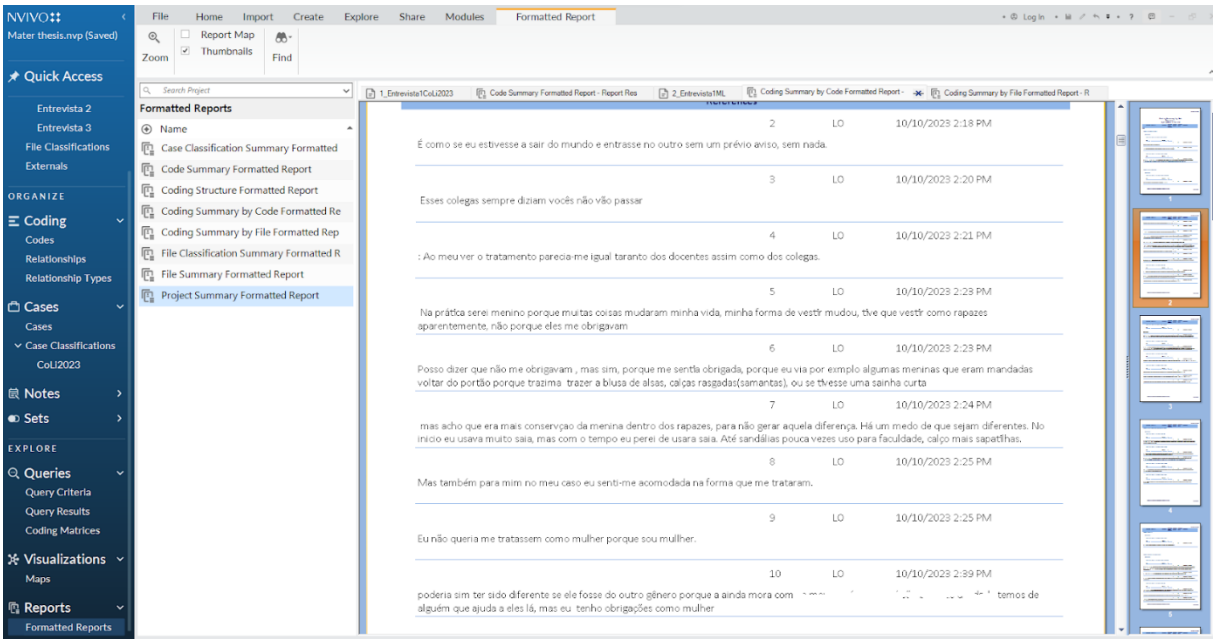


*Figure 6: NVivo Coding Summary*

## 3.7. Ethical Considerations

This research followed the UCT Research Ethics Code for Research Involving Humans. Williams (2009) highlights ethical concerns in research conducted in one's "own backyard", noting the possibility of the researcher knowing the interviewees, being an insider researcher. Such familiarity can pose ethical dilemmas, like risking participant well-being, breaking trust, or exploiting vulnerability. Williams (2009) suggests measures to maintain ethical standards, including obtaining signed consent forms to ensure participant confidentiality and data safety, thus preventing coercion or manipulation during interviews. Aligning with Williams (2009), participants signed consent forms, which outlined data management, privacy, harm prevention, and also reminded that their participation in this research was voluntary.

There was concern about participant comfort with publishing their opinions, especially given the personal nature of some interview questions about their colleagues and university. The in-depth interview method and detailed data collection posed identification risks if disclosed. To mitigate this and protect anonymity, participants were assigned aliases, and data was coded to avoid publishing raw data. Additionally, two students willing to participate were excluded due to identifiability risks as they were the only women in their courses. Detailed demographic data was not disclosed during selection to prevent identification. After transcription, data were also returned to participants for verification and adjustments, ensuring confidentiality and integrity.

The research proposal, including the Authorization Consent Form, Interview Questions, and Data Collection and Analysis Strategy, was reviewed by the Department Head and Ethics

Committee for ethical approval. Following clearance, permission was also obtained from the Vice Director of Research and Extension at UEM's Engineering Faculty. Only then were potential participants invited to join the study.

## 3.8. Validity

Crucial methods were used to enhance this study's credibility and mitigate validity threats in qualitative research. Validity measures how accurately results reflect the phenomena studied (Mustafa, 2011). The three interviews structured arrangement, consistent timeframes, coherent excerpts, and deep participant understanding from the interview reinforced the confidence in their truthfulness.

In his 2004 study, Shenton (2004) explored trustworthiness in research, highlighting the need for credible, transferable, dependable, and confirmable investigations. Shenton (2004) emphasised that trustworthiness hinges on the research methodology's integrity and the findings' validity, crucial for enhancing the study's reliability and applicability. The approaches to ensure the current study's trustworthiness closely followed Shenton's (2004) framework, incorporating key measures:

- **Credibility**: The research adhered to Fraser's social justice framework, a well-established framework that addresses complex social justice issues across three dimensions. This framework broke down complex issues into more manageable segments (dimensions of Fraser), providing a comprehensive guide to the study and enhancing its credibility.
- **Transferability**: Data gathering involved a three interviews protocol, with the final session emphasising reflection and participant feedback. This technique not only ensured the authenticity of the collected data through triangulation but also allowed participants further insights and corrections. Such detailed and participant-validated data collection enabled a nuanced understanding of the studied phenomenon, increasing the applicability of the findings in similar contexts.
- **Dependability**: The research included a data management plan established before the study began, essential for data integrity and preventing misinterpretation, ensuring dependability of the research outcomes.
- **Confirmability**: Given the researcher's deep involvement in the study, steps were taken to ensure that the findings reflected the data and not the researcher's personal biases. Participants were invited to review the collected data and provide feedback on preliminary findings, ensuring their voices were accurately represented in the final analysis. The transcribed interviews were shared for additional feedback, which was crucial for maintaining data accuracy and impartiality. Furthermore, the use of Nancy Fraser's social justice framework provided an objective lens, focusing on structural

injustices rather than being guided by the researcher's personal narrative, thus guiding the data analysis in a balanced and systematic manner.

## 3.9. Conclusion

This chapter outlined the methodological approach employed to explore how educational technologies can foster inclusivity for female students in engineering at UEM. By adopting a qualitative, interpretive framework, the study captured the lived experiences of participants, providing a deep understanding of the social injustices they face and the potential of EdTech to address these barriers. The use of Seidman's three-interview technique, complemented by the River of Life method, allowed for rich, nuanced data collection that highlighted personal and educational journeys. Through careful participant selection, data collection, and thematic analysis, this chapter set the foundation for uncovering the role of EdTech in creating more inclusive learning environments, ensuring that the voices of underrepresented groups are heard and valued. Through these meticulously designed strategies, the study aimed to affirm its trustworthiness, adressing and mitigating the inherent biases and obstacles associated with characteristics of qualitative research. The next chapter will present the findings and offer insights into the practical implications of these methodologies.

# 4. Chapter 4: Findings

## 4.1. Introduction

In the pursuit of understanding the intricacies of women's experiences in STEM, particularly in engineering undergraduate courses at UEM, this study embarked on a qualitative journey to disclose often unheard narratives. The underrepresentation and inclusion of women in STEM constitute a complex web of personal, cultural, and institutional aspects demanding meticulous and empathetic exploration. The insights presented here emerge from the narratives of six women who have navigated the challenges and triumphs of pursuing engineering. Each, with a distinct life story, shared her voice through three in-depth interviews (Seidman, 2013). Together, they offered a multifaceted view of their educational and life journeys. Through these conversations, these women painted a vivid and deeply personal picture of their lives, providing not just responses but a profound understanding of the studied phenomena through their mosaic of stories. The journey began by detailing each participant's background, setting the stage for an in-depth exploration of the emerging themes. While initially these themes were individual, threads connected the participants in shared narratives.

Navigating their stories revealed the critical influence of mentors, role models, and family support. The widespread shadow of self-doubt, common in uninviting environments, was encountered. Gender stereotypes, an undesired inheritance, frequently emerged and were contested by participants. Technology manifested as more than just a tool, but as a transformative agent, reshaping academic and personal lives. Financial support through scholarships proved crucial, emphasising the role of financial aid in shaping educational and professional opportunities.

Various forms of empowerment were also encountered, to be explored in the next sections, showcasing the human spirit's ability to overcome obstacles and redefine potential. By unpacking these themes, the goal was to offer more than observations, there was a pursuit of a deeper, more empathetic understanding of the factors shaping the trajectories of female students in STEM and how EdTech potentially influences these paths.

The word cloud (Fig.7) from participant narratives serves as a visual testament to the multifaceted experiences of female engineering students at UEM. Each word, sized by its importance, echoes their collective voice, highlighting 'Learning,' 'Visibility,' and 'Representation' as central to their academic journeys. It maps challenges and resilience, capturing their stories' essence from 'Gender' and 'Cultural Barriers' to 'Empowerment' and 'Support'.

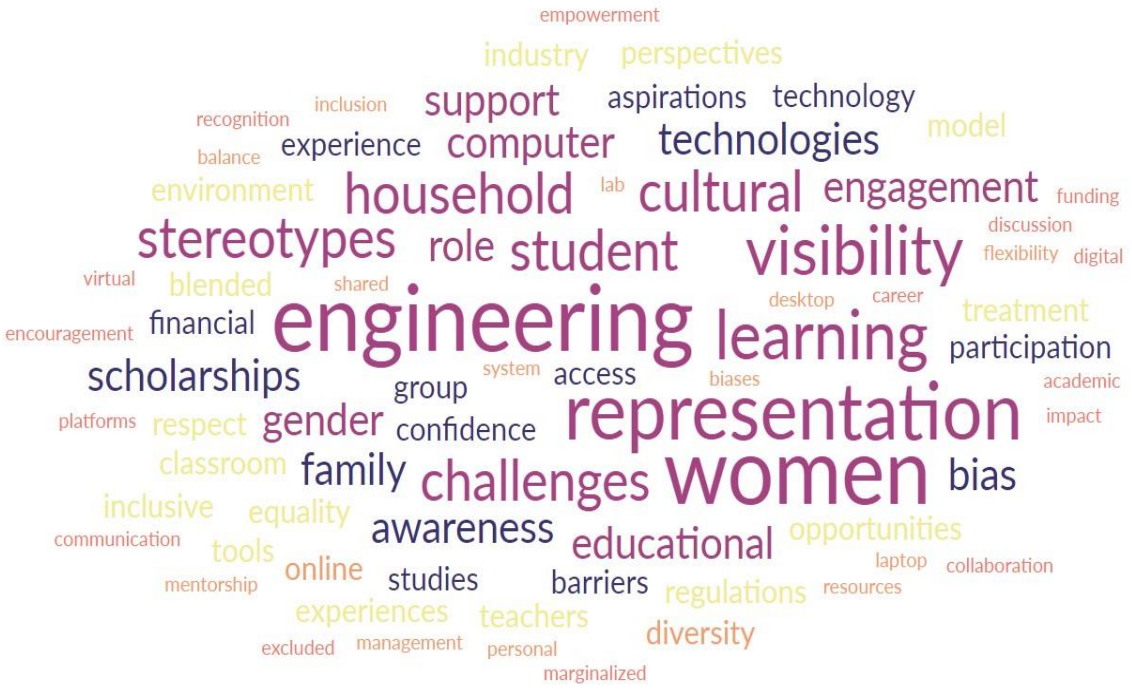


*Figure 7: Word Cloud of Coded Words From Nvivo*

The insights from these interviews are interlaced with the broader discourse on gender in STEM and reflect participants' interactions with EdTech. Presented as overarching themes that emerged during data analysis, they tell parts of these women's collective stories at UEM. These themes represent their actual experiences, resonating with their stories and realities and how EdTech might shape women's paths in STEM.

## 4.2. Getting to Know Women in STEM

The diverse experiences of six participants from UEM from diverse backgrounds, aged 20 to 30 were explored. These women[1], each at different stages in their academic journey, shared their stories through a series of interviews, using the River of Life technique to visually represent their narratives, enhancing our understanding of the role of EdTech in their academic and personal lives.

Laura and Larissa both began their educational journeys influenced by strong familial support and a structured environment. Laura's path in engineering was shaped by early exposure to digital tools and her mother's encouragement to overcome shyness and social barriers. Similarly, Larissa, despite health challenges that limited her physical activities, was inspired by

[1] To delve deeply into our participants' stories, see Appendix F.

her brother's engineering studies and received firm support from her family to pursue her own path in engineering.

Sofia and Isabel, on the other hand, faced significant disruptions in their early lives. Sofia's childhood involved moving back to Mozambique due to her parents' separation, which led to struggles with the Portuguese language and social integration. Her academic performance initially suffered despite good grades, which didn't truly reflect her understanding. Isabel's crucial academic turning point came when she transferred schools, which led her to a coding programme for girls, sparking her interest in engineering. Both women highlight the importance of overcoming early adversities and the role of technology in facilitating their ongoing educational endeavours.

Maura and Denise share experiences of navigating academic and domestic responsibilities from a young age. Maura was driven by her father's advice and a personal affinity for the exact sciences, which helped her decide on engineering as a strategic career path. Denise, growing up in a large family, was quickly drawn into household duties, which shaped her early responsibilities but also her interest in engineering glowed by a science fair. Both women exemplify how family influence and early academic exposure have shaped their educational choices and helped them manage the dual demands of home and school.

## 4.3. Women's Experiences in Their Academic Career with the Integration of Technology

This qualitative analysis began with a meticulous process of coding data from interviews using NVivo. Through this exploration, we constructed a narrative weaving together the intricate experiences of women engineering students at UEM. The emergent themes captured the essence of their encounters with technology, from the pressing need for personal access to the subtle shifts in dynamics that technology introduces into traditional learning spaces, shown in the mind map below (Fig. 8).

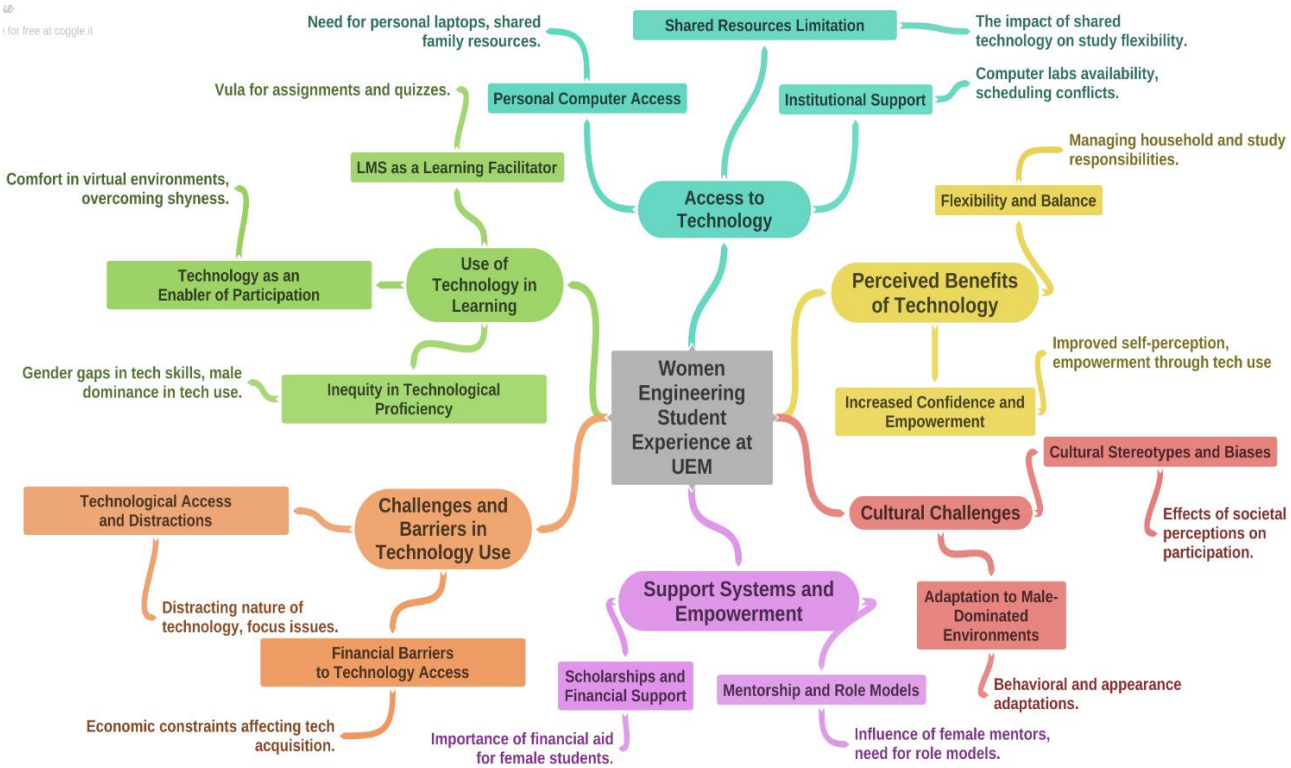


*Figure 8: Themes and Sub-themes*[2]

The findings highlight factors related to technology access: the importance of personal computers in education, managing shared resources, and the role of institutional facilities in either supporting or hindering academic efforts. This exploration was underpinned by economic, cultural, and political currents shaping these women's experiences in engineering. The data revealed cultural scripts dictating behaviour and strategies used by participants to adapt to male-dominated environments. The mind map from our analysis charted technology's impact and the broader societal environment of these women. In the next section, we will explore these themes, unpacking the layers to better grasp their content and significance.

### 4.3.1. Access to Technology

This theme is examined through personal computing access and its impact on female students' educational experiences. Key findings suggest that owning a personal computer is essential for academic participation and success. Students without personal computers face notable barriers to practicing skills and engaging fully in coursework.

Isabel's interviews (Comment 1) describe challenges without a personal computer. Her first year was hindered by not having a laptop, impacting her academic engagement. A scholarship

[2] Refer to Appendix G for table format

enabled her to purchase a graphic calculator for advanced calculus, a tool previously unaffordable, meaningfully aiding her education and highlighting the importance of targeted support in overcoming technological disparities.

> *Comment 1:* "*For me, the essential resource would be the computer. I didn't have a personal computer; I used a shared desktop among three... It was difficult, and there was no way to practice at college... My older sister was the first to get a personal computer; after a few years, she bought another computer and offered me the one she was using. Then I was able to bring a laptop to college. My first year was entirely without an individual laptop.*" (Isabel)

The limitation of shared resources is a significant barrier. Isabel had to share a desktop with two others, severely restricting her study time and flexibility. This impeded her ability to practice and engage effectively with her coursework. In her home, the shared computer meant uncertain access, directly impacting her academic performance.

Sofia's narrative echoes similar struggles, highlighting reliance on a communal computer lab due to not having a personal laptop. The lab's dual role as a classroom and study space creates accessibility barriers, such as restricted access and potential overcrowding, making it hard for students like Sofia to find time and space for assignments (Comment 2).

> *Comment 2: "I didn't own a laptop, which was necessary to complete tasks. However, the college has a computer lab... But the computer lab is also used for classes, so sometimes it's hard to access the lab when you need it."* (Sofia)

Institutional support, while present, was found to be inadequate due to accessibility issues. Sofia's reliance on her college's computer lab exemplifies the challenge of accessing institutional resources. Although the lab provides the necessary technology, the lab's dual use for classes and as a study space limits its availability, creating a competitive environment for computer access, which disrupts study schedules and affects task completion timeliness.

These experiences contrast sharply with Denise's, who recognises (Comment 3) the fundamental role of educational resources, like laptops, in academic success. Denise emphasises technology's central importance in modern education.

> Comment 3: *"In my opinion, in terms of resources, I believe the most important are educational materials, including a laptop, bag, and a phone. I think these resources are indispensable."* (Denise)

Furthermore, Maura's perspective illuminates another dimension of this issue. With uninterrupted access to a personal computer, she views the laptop as crucial for using software and accessing course content, possibly overlooking a privilege that others lack (Comment 4).

> Comment 4: *"The main thing would be the laptop due to the use of software and the need to access course content ... A cell phone with at least minimal storage and processing*

*capabilities is also important... I believe that whether or not I get a scholarship, my parents would be able to support my studies."* (Maura)

Comment 5: *"I never had financial difficulties. When I entered college, I already had a laptop that I received for my birthday... later, while at college, I upgraded to a better processing and performance"* (Larissa)

These experiences reveal a disparity that extends beyond technology to socio-economic issues. For students like Maura and Larissa, who have never faced resource difficulties, the issue of technology access may not be clear (Comments 4 and 5). This discloses a socio-economic divide where access to personal computers significantly influences educational outcomes.

These extracts highlight a broader issue: access to personal technology is essential, not merely convenient. It's an equity issue with direct academic implications. Students without stable technology access see compromised academic potential. Isabel's shared desktop use creates blocks, reducing practice time and causing assignment delays and stress. Sofia's experience emphasises the need for institutional resources to be accessible when students need them the most, not merely having them.

### 4.3.2. Use of Technology in Learning

This theme explores LMS as pivotal in facilitating learning aspects. Key findings indicate that, although the LMS platforms, such as Moodle, enable communication, and collaboration, with potential to enhance interactive and active participation, they were most often used as content and assessment management tools.

Laura's appreciation for the user-friendly nature of LMS platforms highlights their broad utility. These systems are interactive, reducing the pressure of real-time responses and allowing thoughtful reflection on contributions. Laura notes this contributes to a less stressful learning environment, alleviating immediacy pressure and enabling deeper engagement with material (Comment 6).

Comment 6: *"I think that Vula was much easier to interact with because I didn't feel so pressured as it wasn't real-time and I could think better about my response. I felt less pressure."* (Laura)

Isabel emphasises (Comment 7) Moodle's practical use for submitting work and conducting tests and quizzes, highlighting its role as central for course requirements. This streamlined approach simplifies assignment and assessment processes, allowing students to focus more on content and less on administrative coursework aspects.

Comment 7: *"We used Moodle, it was primarily used for submitting assignments, sometimes for tests, online quizzes, and often to access course materials."* (Isabel)

Sofia highlights Moodle's effectiveness for interactive activities, especially peer assessments in workshops. Its asynchronous nature provides a buffer for considered and reflective feedback, contrasting with the haste of real-time interaction (Comment 8). This shows how well-integrated LMS features can enhance collaborative learning.

> Comment 8: *"In two courses, we used Moodle for interactive activities... they were workshops for peer assessments. Being online within a specified timeframe was helpful... no pressure to respond immediately or provide direct feedback; more time to reflect... these courses were taught by the same professors."* (Sofia)

Denise's use of Moodle was primarily for forums, and accessing course materials (Comment 9). Though less interactive, it stresses LMS's role as a critical repository and communication tool, essential for information dissemination and dialogue among students and faculty.

> Comment 9: *"We only used Moodle's chat and forums in one course. But as time went on, we mainly accessed Moodle to retrieve course materials."* (Denise)

Lastly, Maura (Comment 10) highlights a diversification of learning tools, with WhatsApp, Google Meet, and Google Classroom complementing Moodle. Her experience suggests a shift towards a varied platform ecosystem, not just LMS reliance. Maura used Moodle for accessing and submitting course materials, while interactive activities occurred on other platforms.

> Comment 10: *"We didn't use Moodle for interactive activities; we relied on WhatsApp, also used Google Meet and Google Classroom. Regarding Moodle, I used it to view course materials and submit assignments."* (Maura)

These findings and participant extracts illustrate that, while the LMSs, like Moodle, are essential for centralising course content and administrative tasks, their use in enhancing interactive learning varies. Moodle is acclaimed for its ability to streamline processes like assignment submissions and content access. However, the extent to which it fosters engaging and participatory experiences is inconsistent. Some students benefit from its collaborative features, while others find combining Moodle with other communication tools more effective. This suggests that, although LMS platforms have the potential to support learning management, their potential to enrich the educational experience through interactive tasks could be better realised, indicating space for improvement in leveraging LMS capabilities to create a more engaging learning environment.

The theme 'Use of Technology in Learning' highlights technology's multifaceted role in enhancing or inhibiting student engagement. Key findings suggest that, while technology enables participation for some, it also surfaces issues, like gender inequity, in technological proficiency and potential digital distractions.

One of the key findings is that technology serves as an enabler of participation, particularly for those uncomfortable in traditional classroom settings. Isabel (Comment 11) highlights how

virtual platforms offer a comforting environment for shy individuals, particularly women in male-dominated fields, by allowing participation without the fear of being physically observed by peers and instructors. This anonymity fosters a more relaxed engagement atmosphere, freeing individuals from the pressure of public scrutiny. Denise (Comment 12) supports this viewpoint, finding comfort in the anonymity of chat platforms like WhatsApp, which promotes more frequent and relaxed interactions away from the gaze of onlookers. These insights evidence technology's role in providing alternative avenues for those who might remain silent in conventional classroom environments.

> Comment 11: *"I think it can play a role since some may feel shy speaking in front of colleagues and teachers, and virtually, one might feel more comfortable unseen... it can help... online learning eliminates the pressure of being watched when answering..."* (Isabel)

> Comment 12: *"[...]using chat platforms like WhatsApp was very helpful. I interacted more without being watched. It was easy since no one could see me."* (Denise)

However, Maura introduces a contrasting perspective, suggesting a gender gap in technological proficiency where men are perceived to have a natural inclination towards technology. This bias implies men may dominate discussions in technological environments, potentially affecting women's engagement and utilisation of educational technologies.

Laura's experience (Comment 14) supports technology's enabling aspect, appreciating its ease of interaction. However, she also acknowledges its dual role as both facilitator and distractor, noting how attention can disperse. While face-to-face interactions on campus may lead to unproductivity, online environments amplify distraction potential, requiring self-regulation. Laura's insight on gender behaviour patterns within technology use suggests that women may engage less due to hesitancy or fear of judgment. Larissa's account (Comment 15) presents a positive perspective, where online project presentations were less challenging than in-person ones, indicating technology's ability to reduce communication and presentation barriers.

> Comment 13: *"Due to men's inclination towards technology, they dominate this area more compared to women."* (Maura)

> Comment 14: *"I use various platforms, and they are easy to interact with. But it's easy to lose focus, although being on campus in person also takes a lot of time, and you can go home without having learned anything… In video conferencing classes, students tend not to participate, especially women, preferring not to speak… I don't think I ever raised questions in the online forum; I always thought, what if my question is absurd? Then it gets recorded for everyone to see."* (Laura)

> Comment 15: *"I was able to express myself better on a digital platform because I didn't have to look at anyone, so I was less nervous... I even defended my points better this way … I didn't have to see anyone staring at me… And the second time, the project presentation*

*was online and it was much better. I managed to present everything and answer all the questions."* (Larissa)

The contrast in participants' experiences expresses the complex relationship between students and educational technologies. While technology can democratise participation, it also exposes biases and inequalities. Laura's reluctance to pose questions online highlights the need for educational settings that foster confidence and gender equality. Additionally, technological distractions are pertinent: easy access to platforms can lead to focus loss, reducing engagement quality. This shows that, while technology offers new interaction avenues, it requires greater self-regulation to manage distractions.

### 4.3.3. Perceived Benefits of Technology

Technology can provide advantages in flexibility, especially for female students balancing home duties alongside academics. Larissa's experience highlights technology's role in enabling access to information and fulfilling academic duties from home (Comment 16). This flexibility integrates household responsibilities with educational tasks, supporting a self-paced learning approach and reducing the need for physical presence at educational institutions. Sofia echoes this sentiment (Comment 17), stressing the improved communication and collaboration digital tools offer. Using WhatsApp and Google Docs for group projects allows asynchronous contributions, facilitating teamwork from any location. This advancement in ICT makes contributions visible and streamlines collaborative work.

Furthermore, Sofia makes a note of (Comment 18) the reflective space online interactions offer, reducing pressure for immediate responses and enabling thoughtful participation. She also highlights economic benefits, like saving on transportation and materials, particularly valuable for those facing significant costs from accessing physical resources, like libraries.

Comment 16: *"Overall, technology helped me a lot in searching for information…when you're at home, it makes things much easier because you have your household chores indoors, you can manage your time to do the tasks and keep up with college activities, doing them at your own pace without needing to be physically present at the university."* (Larissa)

Comment 17: *"There was an advancement. I can communicate with my colleagues at anytime, anywhere. For example, in group work, we use WhatsApp, Google Docs, and each person can add what they want, and everyone can see it."* (Sofia)

Comment 18: *"The fact that it was online and we could do it within a specified timeframe was very helpful... There was no pressure to respond immediately and provide direct feedback; we had more time to reflect... Being at home allows me to do research work without having to travel to a physical library on campus. I also don't have to spend money on transportation..." (Sofia)*

Comment 19: *"Regarding the management of household chores with school activities, I think technology helps women more than men."* (Isabel)

Isabel further supports these findings, suggesting that technology aids women in balancing household and school duties (Comment 19). The shift to online platforms provides an anonymity level, empowering those who might feel overlooked in face-to-face interactions (Comment 11). Digital formats, such as WhatsApp groups and online forums, ensure contributions are acknowledged and recorded (Comment 20). Moreover, Isabel appreciates the financial relief from technology, saving on transportation and costs of textbooks and materials (Comment 21).

Comment 20: *"In face-to-face discussions, sometimes I felt that my ideas were ignored, but in WhatsApp groups and online forums, at least my idea would be recorded there."* (Isabel)

Comment 21: *"Sometimes, I also didn't have to deal with the irritation of taking public transportation. Being at home and using technology helped in a way. In financial terms, it also helped because I didn't have to buy physical books, print documents, and sometimes didn't need to spend money on transportation."* (Isabel)

When examining these accounts, a coherent picture emerges: technology is a potential enabler, which allows women to integrate their academic pursuits with other life responsibilities effectively. The participants' narratives underline the transformative impact of EdTech facilitating a more balanced, inclusive, and economically feasible approach to learning for women juggling multiple responsibilities.

### 4.3.4. Challenges and Barriers to Technology Use

This theme highlights the complex relationship between students and digital tools in education. Key findings indicate that, while technology can aid learning, it also introduces relevant obstacles, such as distractions, financial access barriers, and the exacerbation of the digital divide. The issue of technological access is stressed by participants like Isabel, who, along with others, voiced the challenges posed by not owning a laptop (Comments 1 and 2). The lack of personal devices hampers not only assignment completion but also affects the overall continuity of their education.

Sofia's experience (Comment 22) highlights the double-edged nature of technological communication. Digital platforms, like WhatsApp, provide opportunities like internships, but the vast amount of information can lead important notices to be overlooked, as happened with her with an internship opportunity. This demonstrates how tools designed to connect and inform can also lead to missed opportunities through information overload.

Comment 22: *“I missed an opportunity for an internship even though it was shared… I wasn't paying attention to the group and only saw it on the last day..."* (Sofia)

Laura emphasises the crucial role of self-discipline in online environments, noting the increased risk of distraction in digital learning (Comment 14). This setting, filled with tabs and notifications, requires more personal regulation than on-campus learning. Additionally, she observes that gender may influence technology interaction, suggesting that women might participate less in digital forums due to reluctance to speak up or fear of judgment.

Economic challenges add a complexity layer to technology use in education. Sofia shares a story of a colleague who couldn't afford train fare, missing classes (Comment 23). This illustrates how economic barriers limit educational participation, a critical issue even before digital platforms. Despite digital convenience, technology costs remain a barrier, as Maura notes (Comment 24). She reflected on how scholarships have helped her overcome these barriers, advocating for their continued necessity.

Comment 23: *"I'll speak about a colleague. Often, she used the train and missed days because she lacked fare money. She's among the strongest I've known, facing many challenges throughout the course. If it were me, I'm not sure I could have overcome those financial barriers."* (Sofia)

Comment 24: *"Having a scholarship helped a lot, for those who have more difficulties with financial resources, a scholarship would be very useful."* (Maura)

Maura (Comment 13) introduces a dimension by discussing gender interplay within technology use, suggesting men might have a greater inclination towards technology, potentially leading to their dominance. This could discourage or hinder women's participation and success in fully utilising educational technologies. Larissa highlights the drawbacks of online classes, noting that unfamiliarity with virtual learning often results in passive engagement, with some students merely connecting without active participation (Comment 25).

Comment 25: *"Online classes have disadvantages, possibly due to unfamiliarity. I observed classmates sometimes connecting without paying much attention to the class."* (Larissa)

Participants' experiences show both converging and diverging views on technology's role in education. They recognise the barriers it can pose, such as distractions and financial constraints, but also acknowledge supports that can mitigate these, like scholarships and targeted interventions for digital proficiency. Additionally, the gender aspect Maura mentions highlights societal perceptions that may influence technology engagement across genders, affecting confidence and participation.

### 4.3.5. Cultural Challenges

Key findings highlight the impact of cultural stereotypes, gender biases, and the need for adaptation in male-dominated engineering spaces on women's sense of belonging and self-perception. Participants' diverse experiences reveal navigation through these environments. Laura's story underscores the cultural pressures women face in male-dominated environments, compelling them to conform in order to fit in or be taken seriously. She chose less feminine outfits, like sneakers, to fit in (Comment 26), often causing surprise among peers when showing femininity, reflecting societal expectations to downplay their gender identity in academic settings (Comment 27).

Sofia's narrative also reflects adaptation, describing her gender as a non-issue to blend into the male-dominated environment, essentially seeing herself as one of the men, *"We are all men"* (Comment 29). This suggests a subliminal pressure to suppress her femininity to be part of the group. While her gender identity blends in on campus, it stands out in external interactions. Despite this, Sofia does not feel marginalised within her academic setting (Comment 28).

> Comment 26: *"Female identity isn't recognised, leading us to adapt by dressing less femininely. For instance, I've shifted to wearing sneakers instead of sandals and prefer only loose clothing—blouses, pants, all loose."* (Laura)
>
> Comment 27: *"Once, colleagues were shocked when (another female peer) and I discussed women's boots, saying, it's not possible, you also talk about girly things'—they hadn't heard us before. Another time, wearing ballerina flats also surprised them. Such reactions suggest they don't see us as women."* (Laura)
>
> Comment 28: *"No, I've never felt excluded..."* (Sofia)
>
> Comment 29: *"I've never felt recognised as a woman; we were all men. My relationship with colleagues is complicated; I forget I'm a girl, and so do they. You realise you're a woman when talking to others outside our circle."* (Sofia)

Maura's engineering experience showcases her efforts to conform to masculine norms, impacting her identity and social interactions. Upon entering college, she consciously adopted a masculine persona, changing her appearance and speech to match male-dominated norms (Comment 30). Believing femininity might be seen as weakness, she altered her behaviour. Although later seeing this as unnecessary, these changes, especially her speech patterns, became ingrained, drawing comments from her social circle. Maura's narrative stressed the profound impact of social environments on identity.

Furthermore, Maura sets clear boundaries between her academic and social life, avoiding activities with her male peers outside of school due to their "aggressive" nature (Comment 31). This choice highlights her cautious approach to the social dynamics within her engineering course. It illustrates the complexities women face in male-dominated fields, where adapting

often requires substantial changes in behaviour and self-presentation, but also necessitates setting personal boundaries to maintain a level of comfort.

> Comment 30: *"When I entered college, I had a masculine personality, dressed and talked in a masculine way...they can't see me as a little woman, otherwise, they'll see me as weak… But over time, I realised it was just childishness... But the personality I haven't been able to change anymore, because I hang out a lot with them, and even my way of talking has changed completely... Even my brother-in-law used to reprimand me..."* (Maura)

> Comment 31: *"What I don't do is hang out with them outside the academic environment, go out at night. I think their outings are too aggressive for me. I socialise more with them within my academic environment. Outside of that, I don't usually participate, it's very masculine."* (Maura)

Larissa and Denise share more confident experiences with gender relationships in engineering. Larissa is well-regarded by her peers, indicating an inclusive environment without the need for adaptation (Comment 32). Denise reports that her female identity hasn't required changes in her appearance, reflecting peer respect and acceptance (Comment 33). These experiences suggest that some women don't feel pressured to conform, highlighting personal variations in how women perceive and navigate their educational settings.

> Comment 32: *"In general, my classmates treat me well."* (Larissa)

> Comment 33: *"Female identity is not set apart... I am respected… I don't think I needed to change anything about my appearance."* (Denise)

Laura highlights complexities around perceived competence, differentiating between being side-lined due to gender and due to assumed lack of ability—an intersection of gender biases. Despite her involvement in an important university project and winning a merit scholarship, her competence is often underestimated without justification, impacting her participation in technical tasks (Comment 34). This scenario shows the overlap of gender and competence biases she faces.

> Comment 34: *"I've never felt excluded due to my gender, but perhaps due to my abilities. Colleagues sometimes think I lack the knowledge or suitability for certain tasks. Despite this, I received another merit scholarship, and I was involved in implementing a crucial university project. Within that team, I was occasionally side-lined, presumably for perceived incapability, not my gender."* (Laura)

Maura discusses the varied attitudes of her peers towards gender identity within her engineering class, observing a complex spectrum of perceptions. She notes that, while some classmates do not discriminate by gender, others may underestimate women's abilities due to negative biases. Conversely, some peers actively offer opportunities for women to enhance their academic performance. This suggests that experiences of gender bias can vary greatly, influenced by

individual character, attitudes, and preconceptions (Comment 35). Despite these challenges, Maura affirms the visibility and recognition of women in her class, noting their intelligence and dedication. She observes that an intelligent woman with a good academic track record is as sought after for group work as a man with similar traits, showing respect for their contributions and understanding their value in the academic community (Comment 36). This dynamic indicates that, despite biases, women in Maura's class maintain a significant and visible presence, asserting their capabilities and securing their place within the cohort.

Comment 35: *"It's difficult to talk about gender identity; some colleagues can't differentiate it. Others differentiate negatively, not giving specific tasks to a female student, assuming she won't be capable. But there are other colleagues who, precisely because we have some difficulties, give us tasks to boost our academic performance. I think it depends on the character of the colleagues, including the teachers."* (Maura)

Comment 36: *"In my class in particular, there is representation because we are very intelligent, and committed. And they struggle to have one of us in their groups."* (Maura)

Isabel and Maura report not feeling excluded by gender (Comments 37 and 38), though their perspectives differ. Maura credits early study group formation and positive social interactions for a strong community sense (Comment 37), suggesting that a collaborative atmosphere can reduce feelings of otherness in male-dominated fields. However, Isabel and Laura have experienced subtle gender differentiation. Isabel recounts occasions where women are expected to be distributed across groups due to their minority status, aiming to ensure their sparse presence is evenly spread. While seemingly inclusive, this practice inadvertently highlights their minority status rather than their individual attributes or abilities (Comment 39). Similarly, Laura notes that teachers' well-meaning support for female students, due to their minority status, often unintentionally underlines their distinctiveness, setting them apart from male peers (Comment 40). These experiences reflect a complex interplay where efforts to integrate and recognise women in engineering sometimes unintentionally reinforce the very otherness they aim to mitigate.

Comment 37: *"Thank God I never felt excluded. Because the small groups were formed at the beginning of the class, and we have a lot of affinity. I am very friendly and talk a lot with my colleagues. And we have gotten along well, everyone likes to talk with me." (Maura)*

Comment 38: *"No, I never felt excluded for being a woman. I don't remember. My colleagues, I think they don't make any distinction."* (Isabel)

Comment 39: *"I remember once a teacher asked me to set up a data show. The teacher said that here we are all engineers. Sometimes there is a certain distinction in terms of forming groups, when I and another female colleague form groups together, we are always asked*

*to separate. They say that, in a group there must be a woman, we can't be together because we are few."* (Isabel)

Comment 40*: "Regarding teachers, female identity is recognised. Some teachers tend to give special attention to women because they are a minority and stand out."* (Laura)

Building on previous findings, Isabel, Sofia, and Laura's experiences shed light on gender dynamics in the engineering classroom. They describe a spotlight effect, where being a woman in a male-dominated environment increases visibility and pressure. Isabel discusses the pressure of being a minority, frequently singled out by teachers for tasks, intensifying performance scrutiny (Comment 41). Similarly, Sofia, often the only woman in class, feels excessively prioritised by teachers, adding undue pressure (Comment 42). Laura's narrative highlights the mixed effects of this attention. Although meant to support, it often translates into overwhelming pressure to perform impeccably, leading to discouragement when failing to meet such high standards (Comment 43).

These experiences highlight a pattern of heightened expectations and analysis. The visibility can lead to more support but also to excessive performance pressure, creating a stressful environment. While efforts to support and include women are well-meaning, they can sometimes result in disproportionate pressure to positively represent their gender.

The similarities in these experiences are outstanding. Despite their diverse backgrounds, Isabel, Sofia, and Laura all report increased expectations and scrutiny, common in minority experiences. Their stories highlight how visibility can be both advantageous and detrimental. It can lead to enhanced support and engagement but may also result in excessive performance pressure, creating a stressful and challenging environment for women. Well-intentioned inclusivity efforts by educators can inadvertently lead to disproportionate pressure on female students to positively represent their gender.

Comment 41: *"Because we were a few girls, there was always that pressure. Being few, the teachers would always point us out for tasks or to answer questions. Being a minority puts us in the spotlight. Whenever the teacher asked something, I felt pressured, I knew I should answer before he pointed me out."* (Isabel)

Comment 42: *"The treatment by teachers and classmates was generally the same. However, teachers tend to prioritise the women, or in my case, as the only woman. If a question arose, I knew I'd respond first because they often said, 'Let the woman speak first, then others.'"* (Sofia)

Comment 43: *"In the classroom, teachers focused more on us girls, then just two. This automatic attention bothered me; I preferred equal treatment. We were forced to be perpetually prepared for intervention, while boys relaxed, knowing they wouldn't be called upon. This emphasis on making us stand out increased our pressure. We had to be*

*constantly ready and knowledgeable, which, if unmet, felt awkward and discouraging."* (Laura)

The pattern that emerges among the experiences of Sofia, Isabel, Maura, Laura, Larissa, and Denise is one of complexity and contradiction: they are simultaneously adapting to fit in, while not necessarily feeling excluded. Although they do not explicitly feel excluded, there is a sharp contrast between this and the adaptations they make to assimilate, indicating a form of implicit pressure to conform to the prevailing norms of their environment. For example, Laura changed the way she presented herself to fit in academically, while Larissa's positive interactions may suggest a genuinely inclusive environment. Denise also did not feel excluded and did not feel the need to alter her presentation, suggesting a level of inclusion among her peers. Synthesising these experiences, it is clear that, while the participants did not explicitly feel excluded due to their gender, they navigated a landscape where gender stereotypes and biases subtly influenced their participation and self-perception, ranging from nuanced forms of differentiation to more direct underestimations of capability, all within a predominantly male environment.

### 4.3.6. Support Systems and Empowerment

Female engineering students highlight the critical roles of mentorship, role models, family support, and financial aid in promoting an environment where women can excel academically. The impact of female mentors and role models is crucial. Sofia points out that forums and discussions featuring successful women engineers can inspire and guide younger female students, creating a sense of possibility and belonging (Comment 44). The visibility of women who have navigated the challenges of a male-dominated field and succeeded can serve as a powerful motivator for aspiring female engineers.

Isabel discusses how programmes encouraging women to tackle challenges and persist in engineering can demystify gender-specific course stereotypes and empower women to succeed in any field (Comment 45). Maura highlights (Comment 46) the pivotal role of mentors in shaping one's academic journey. Her father's ongoing guidance and the support from her tutor in the 12th grade, who was an engineering student, have been instrumental in her development. This mentorship has not only fostered her success but also bolstered her confidence, illustrating the profound effect of mentorship on academic trajectories.

Comment 44: *"Having forums, the younger ones will see that there are women already on this path."* (Sofia)

Comment 45: *"More programmes could teach and encourage women to persist and challenge norms, emphasising that all courses are open to them without distinction between*

*courses for men or for women. Being in a different environment like this can be challenging."* (Isabel)

Comment 46: *"My father still advises me to this day. I often say he's my best friend... but also, my tutor in the 12th grade was a student here at the engineering faculty. He supported me a lot."* (Maura)

Financial support is another critical enabler. Scholarships and funding opportunities can alleviate the economic burden that might deter capable students from pursuing or continuing their engineering education. Maura emphasises the vital role of scholarships in overcoming financial barriers, especially for those in difficult economic situations (Comment 24). Her insights stress the need for robust financial support systems, which are vital for assisting women in HE, allowing them to concentrate on academic challenges without financial worries. On the other hand, Laura's reluctance to participate in scientific conferences suggests a potential area where these support systems could further intervene (Comment 47). Encouraging and preparing female students for these events could enhance their engagement in academic discourse and visibility.

Comment 47: *"For example, at the engineering faculty's events like the scientific conferences, I've never seen a woman of our course participate; there might have been one, but not to my knowledge. I even avoided the application processes for these conferences."* (Laura)

Denise, while not identifying specific barriers, acknowledges that there could be room for improvement in supporting women in engineering, though she's unsure what form that support should take. This uncertainty itself is telling, suggesting that the need for support may not always be apparent to those who could benefit from it (Comment 48).

Comment 48: *"I've never thought about this; I don't think there's anything that bothers me. But to say that nothing could be done would not be true; I just don't know what it would be. It's something to think about deeply."* (Denise)

Maura touches (Comment 50) upon institutional support by considering adjustments to academic regulations to accommodate life events, such as maternity, that predominantly affect women. This consideration for the intersection of academic, professional, and personal life is crucial in creating a supportive and equitable educational environment.

Comment 50: *"The current regulations are adequate. They shouldn't change based on gender… However, considering family aspects, such as extending course durations for maternity, could be beneficial, like maternity leave."* (Maura)

Participants' views show varied satisfaction with existing support systems and differing views on necessary empowerment initiatives. While some call for more proactive support, others are satisfied with the current state or unsure of needed changes. Their experiences indicate a need

for more targeted programs offering mentorship, showcasing female role models, and providing financial and structural support. These efforts can foster an environment that not only welcomes but also actively supports women in engineering, recognising their unique challenges.

## 4.4. Conclusion

This chapter has explored the personal and academic narratives of six female engineering students at UEM, unveiling experiences shaped by familial support, personal adversity, and technological integration. Their stories reveal how gender, culture, and technology intersect, highlighting barriers and opportunities within STEM education. Key findings indicate that access to technology is not merely a convenience but can significantly influence academic engagement and success. However, this access remains unevenly distributed, illustrating a clear divide within the educational system. The insights into the use of technology show its dual capacity both to facilitate and impede learning, with institutional support systems often falling short of fully harnessing its potential.

Cultural stereotypes and adaptation to male-dominated environments have emerged as pervasive challenges, affecting the women's sense of belonging and self-perception. These cultural barriers illustrate the persistent need to challenge societal norms that often sideline women in engineering fields. Meanwhile, empowerment narratives centered around the availability of mentorship, visible role models, and financial support highlight essential strategies for fostering environments where women can thrive academically. The findings advocate for a more concerted effort to develop targeted support mechanisms, ensure equitable access to technology, and initiate cultural change within STEM education. By addressing these critical areas, we can better support the aspirations of women in engineering, enriching the field with diverse perspectives and enhancing overall academic and professional landscapes.

# 5. Chapter 5: Discussion

## 5.1. Introduction

This discussion chapter delves into the multifaceted role of EdTech in fostering the inclusion of women in the STEM fields at UEM, guided by Fraser's (2005, 2009) theory of participatory arity. The investigation is anchored in a qualitative analysis that explores the economic, cultural, and political dimensions of social justice within the context of STEM education. By integrating the theoretical underpinnings of Fraser's work with the findings, this discussion aims to illuminate the pathways through which EdTech can have an enabling and inclusive effect, providing a potential mechanism for women to participate equally in learning in the STEM field.

The economic barriers that disproportionately hinder women's participation in STEM are examined, alongside the transformative potential of technology in mitigating these obstacles. This examination is coupled with an analysis of the cultural dynamics that shape women's experiences in engineering, highlighting the role of technology in challenging entrenched stereotypes and fostering a more inclusive academic environment. Furthermore, the political dimension of social justice is analysed, focusing on the support systems and policies that are critical for empowering women in STEM fields. Through this comprehensive analysis, the chapter seeks to answer a pivotal question: How can EdTech be leveraged to increase women's inclusion in STEM fields?

## 5.2. Fraser's Social Justice Framework as an Analytical Lens

Fraser's framework, centered on "Participatory Parity", provides a deep lens for examining social justice by advocating for a society where everyone can engage equally in all life areas. Fraser's three dimensions—economic, cultural, and political—must be addressed to dismantle institutional barriers to social justice. This approach aims to foster an environment where each individual contributes to democratic discourse and decision-making, ensuring all voices are equally heard and valued.

Through an in-depth analysis, this discussion uncovers multiple layers of economic, cultural, and political challenges that impact women's inclusion in STEM fields. The chapter highlights economic barriers such as limited access to technology and financial resources, cultural injustices rooted in gender stereotypes within the male-dominated engineering environment, and political gaps in the implementation and awareness of gender-focused policies. By examining these dimensions, the chapter aims to provide a comprehensive understanding of the social injustices that hinder women's full participation and success in graduate engineering courses at UEM. Further explored in the next sections.

## 5.3. Economic Dimension of Social Justice

### 5.3.1. Access to Technology

The literature presents a consistent view regarding the impact of limited access to resources on student success, particularly among female students (Gredley, 2022; Samulewicz et al., 2012). It underscores the economic barriers that disproportionately affect women's engagement and academic achievement. This inequity is recognised as a form of economic injustice, echoing Fraser's (2009) perspective, and is not merely an obstacle to completing assignments but a symptom of systemic inequality that frictions with the educational journey for these women.

The studies by Begum et al. (2022), Bosch and Pondayi (2022), Greider et al. (2019) and Samulewicz et al. (2012) suggest that women are more adversely affected by economic injustice due to inherent gender biases. This perspective aligns with broader observations within the field of technology access and gender studies, indicating that systemic issues often disproportionately impact women, creating barriers to technology access, career advancement in STEM fields, and overall economic opportunities.

However, this study reveals that participants do not directly link their economic difficulties to gender; they associate these challenges with society's socio-economic conditions. This outcome may be influenced by the sample's demographics. All participants live in the country's capital, an urban environment typically associated with better socioeconomic conditions than suburban or rural areas. Urban settings often offer more robust educational systems, greater access to technology, and more economic opportunities (Maarseveen, 2021). These factors can obfuscate some technology access barriers more pronounced in less urban areas.

Moreover, these women’s pursuit of HE suggests that they come from supportive family environments. Access to HE often requires financial stability and a family structure that values education for all children, regardless of gender. In financially constrained families, resource allocation for education can reflect societal biases, preferring boys' education over girls' (Begum et al., 2022). The participants' backgrounds indicate that they are not from this demographic, hence they are excelling, supporting the notion that sibling resource allocation should not be influenced by gender.

The participants' backgrounds indicate that they do not belong to this demographic, hence they are excelling, further supporting the notion that the resource allocation among siblings should not be influenced by gender.

From the findings, the participants highlighted the importance of having personal computers and reliable internet access. The shared use of desktop computers at home and limited access to laptops was a common challenge, affecting their ability to engage with digital resources and

participate fully in coursework. Although the evidence from the findings points to this disparity, it is important to acknowledge that the issue of technology access is not exclusive to women (Bozalek, 2017). However, it affects them differently because, for them, dedicated time for academic activities should be shared with domestic responsibilities, as we will see later in this chapter.

Furthermore, another scholarly voice (Drew, 2015) emphasises the critical importance of ensuring that the integration of technology into educational environments does not further marginalise minority groups. The intention is to harness technology as a tool for inclusion and equity, rather than allowing it to become a catalyst for increased alienation of those already at a disadvantage. Therefore, the conversation around technology access in education is not just about providing resources but also about fostering an inclusive culture that supports all students equally.

The literature (Drew, 2015; Eden et al., 2024; Gredley, 2022) indeed reflects institutional efforts to counter the technological access barriers faced by students from lower economic backgrounds and how this kind of effort can be a transformative redistribution. The establishment of an informatics lab within the faculty is a tangible example of these efforts. It is designed to provide students, who cannot afford personal technology, the resources to participate fully in their educational pursuits. Participants' experience highlights the value of this institutional support; for those without personal computers or internet access, the informatics lab becomes an essential resource.

However, participants' narratives show limitations of communal facilities. While the lab provides technological access, its dual function as classroom and study space presents challenges. Access times are limited, and the space becomes overcrowded during peak periods, complicating the situation for students needing quiet environments to focus on assignments. This points to the need for a more nuanced approach to institutional support—one that provides technological resources and ensures they are accessible when and how students need them (Eden et al., 2024). For women, the challenge is magnified by the dual burden of academic and domestic roles. Findings show women still handle domestic chores and caregiving while pursuing their education. These responsibilities limit schedule flexibility, making it harder to navigate limited access times and overcrowding. When facilities are available only during hours that clash with domestic responsibilities, women students are at a disadvantage, unable to fully utilise these resources.

Gredley (2022) points out that scholarships and financial aid serve as pivotal facilitators of economic justice within the educational realm. They are instrumental in alleviating the economic burdens that disproportionately hinder female students from fully engaging with and succeeding in their academic endeavours. The provision of financial support not only eases immediate monetary constraints but also represents a strategic investment in the future of

students who might otherwise be compelled to abandon their educational aspirations due to financial hardship.

Student loan programmes enable access to HE, especially for less privileged backgrounds. These loans remove financial barriers, allowing students to pursue degrees leading to better job prospects and higher earnings (Canton & Blom, 2004). Student loans are vital for individual advancement and societal progress, making them indispensable in modern education systems. In contexts like Mozambique, where student loan programmes are unavailable (Joaquim, 2023), scholarships become more important. The absence of loans means students face greater challenges in financing education, making scholarships and institutional aid essential for access. University scholarship programmes for students facing financial hardships, with specific selection criteria, highlight the importance of institutional support in bridging the financial gap (Enriquez et al., 2014). These programmes create an inclusive and equitable educational environment where economic barriers do not preclude talented students from pursuing HE.

Financial aid and scholarships play an important role in advancing economic justice in HE. Four out of six participants benefited from scholarships by a local extractive sector company, specifically aimed at women in engineering. This support alleviates financial barriers for women and reflects the need for greater gender diversity within the field. Scholarships for women in engineering by local industries indicate a broader push for representativity and diversity in STEM. By offering these scholarships, industries contribute to economic justice by making engineering education more accessible to women, and address the gender imbalance in the sector.

### 5.3.2. Perceived Benefits of Technology

In education, particularly for women in engineering, the economic benefits of technology are important, especially for cost reduction and time management. By enabling educational activities from home, technology significantly reduces transportation costs and eliminates printing expenses with digital resources. This aligns with Fraser's idea of economic restructuring to remove participation barriers (Fraser, 2005, 2009), embodying her framework where redistributing resources levels the economic playing field.

The convenience and efficiency of technology in education, as shown by participants' experiences, highlight the transformational impact of digital tools in managing and optimising time, an essential economic resource. Gredley (2022) emphasises time's value as an important economic resource for women, often scarce. Integrating technology in education settings facilitates a more efficient allocation of time, benefitting all students. This efficiency is crucial in academic environments where the pressures of coursework, extracurricular activities, and, for some, part-time employment, demand careful time management. Students can access learning materials online, participate in virtual classrooms, and use digital tools for assignments

and research, streamlining their educational journey and making it more flexible and adaptable to their schedules.

Although some studies indicate that students prefer face-to-face classes because they lack private workspaces at home and have difficulty concentrating (Dios & Charlo, 2021), this preference is also seen among the women in this study. However, these women argue for the need of an extended home study option because they cannot be on campus all day and are more likely to miss face-to-face classes due to domestic responsibilities. Additionally, because they are often at home juggling various household tasks, they prefer asynchronous academic activities as an extension of the on-campus face-to-face classes.

For women balancing academic pursuits with domestic responsibilities, technology in education is crucial. Digital resources make learning more accessible and flexible, accommodating their challenges. This flexibility enables women to pursue academic and career goals while managing domestic roles. Reduced on-campus time due to technology represents a substantial economic gain. Time is a valuable resource (Gredley, 2022). Technology's flexibility allows students, especially those with multiple responsibilities, to manage their time more effectively (Ossiannilsson, 2018). This is particularly beneficial for women in engineering, juggling academic, domestic, and professional duties. Accessing lectures, resources, and completing assignments online provides more time for other tasks, enhancing their economic and personal well-being. Thus, technology serves as both a facilitator of education and an enabler of economic justice (Fraser, 2005, 2009), providing women with tools to manage time and pursue their educational goals.

The shift towards online or hybrid learning and digital resources stresses the economic benefits of technology for students. Engaging in academic activities from home or remote locations reduces the need for transportation to campus (Dios & Charlo, 2021), leading to substantial savings on transportation costs over time, as noted by the participants. These savings are particularly impactful for students living far from their institutions or relying on public transportation, easing the financial pressures of pursuing HE. Moving from printed materials to digital resources also exemplifies economic justice. Participants noted that reduced printing needs translate to cost savings and environmentally sustainable practices. By democratising access to educational content and reducing financial burdens, technology promotes economic justice, ensuring more individuals can pursue academic endeavours without economic constraints.

Engaging in academic activities from home or remote locations reduces the need for transportation to campus, leading to substantial savings. Participants' comments reflect the economic advantages of technology, particularly in negating the need for printing materials. The shift to digital resources saves money and contributes to economic justice by reducing

financial burdens. The integration of technology in education, especially for women in engineering, offers substantial economic benefits. These benefits include direct cost savings, like reduced transportation and material expenses, and the saving and redistribution of time, a critical economic resource. This dual advantage aligns with Fraser's principles of economic restructuring and breaks down barriers to participation in HE.

## 5.4. Cultural Dimension of Social Justice

### 5.4.1. Cultural context

Responses indicated that, while there has been progress, there are still cultural patterns at play that may impact women's experiences in engineering. The perception that engineering should be a male-dominated field persists, and although faculty may be supportive, there is a sense that more could be done to foster an inclusive environment. Research by Casad et al. (2020) reinforces this, showing that, despite increased female enrolment in engineering, the culture remains unwelcoming due to entrenched gender stereotypes.

The narratives of the participants provide a profound insight into the cultural injustices of the engineering environment, which is male-dominated. This setting influences women's sense of belonging and requires them to navigate persistent gender stereotypes that impact their participation and self-perception (O'Connell & McKinnon, 2021). The women's mere presence in engineering does not dismantle the structural and cultural barriers they face but rather points to a disjunction between the formal inclusion of women in engineering and the substantive, lived experience of being recognised and valued equally which aligns with Fraser's (2005, 2009) idea of injustice of misrecognition.

The participants' shared experiences communicate the implicit pressures to conform to the prevailing norms of their environment. The participants' need to alter their outfits to fit in is a stark reflection of cultural injustice, illustrating how women are often compelled to modify their appearance to be taken seriously in engineering spaces (Eikermann, 2019). This adaptation goes beyond personal choice, serving as a coping mechanism to navigate a field rife with implicit biases.

The recurring theme across these extracts reveals a complex landscape defined by a nuanced interplay of acknowledgement and adaptation. Women in engineering receive recognition for their contributions and intelligence, but this often comes with an implicit expectation to modify aspects of their identity to conform to the prevailing culture. This duality underscores how gender stereotypes and cultural expectations persistently influence women's participation in engineering. Despite being respected and valued, they navigate cultural norms requiring constant reevaluation of how they present themselves (Dutta, 2016). This phenomenon

highlights the ongoing impact of cultural stereotypes and biases, showing that recognition of women's capabilities coexists with pressure to adapt, reflecting the deep-rooted challenges shaping their experiences in engineering.

Interestingly, despite the adaptations made by these women, they did not report feeling pressured to conform to the social norms within the engineering academic environment. This discrepancy highlights the nuanced difference between the perceived necessity for adaptation and the actual experience of pressure (Powell et al., 2009). It suggests that, while the environment may not explicitly demand conformity, the cultural and social undercurrents create a context in which adaptation is seen as a strategy for navigating and succeeding in a male-dominated field.

These narratives highlight that, while outright gender exclusion may not be the norm, the pressure to assimilate into a male-dominated environment can be covert exclusion. This adaptation affects self-perception and authenticity in women's educational and professional engineering journeys. Experiences suggest that, while overt exclusion may not exist, the need to conform to male-dominated environments reveals underlying gender bias. The pressure to change self-presentation, and assumptions about competence based on gender are significant barriers that must be acknowledged and addressed to create a more inclusive and equitable space for all genders in engineering.

The literature highlights the awareness among educators in STEM fields of the importance of fostering a supportive environment for women, acknowledging the historic underrepresentation and unique challenges they face. Research by Smith et al. (2017) accentuates the efforts to create inclusive classrooms that actively engage underrepresented groups, demonstrating a conscious effort to balance participation across genders. Similarly, Kricorian et al.'s (2020) study illustrate initiatives within STEM fields aimed at enhancing the educational experience for women and other minorities, ensuring they receive the encouragement necessary to pursue and excel in these fields.

However, the challenge lies in finding the delicate equilibrium between creating a supportive environment and inadvertently singling out minority students, thereby emphasising their status as outliers rather than focusing on their individual merits. The experiences shared by the participants offer a moving illustration of this dilemma. Despite the well-intentioned efforts to involve and engage female students, these actions sometimes translated into an overwhelming pressure to constantly perform at a high level, as highlighted by the participants. This sentiment is echoed in the work of Girolamo and Ghali (2021), who found that, while targeted support initiatives are crucial, they must be carefully calibrated to avoid placing undue pressure on the individuals they aim to assist.

One of the participants' observations highlights a subtle type of gender differentiation, where the symbolic inclusion of women in various groups unintentionally emphasises their minority status. This observation is supported by the research of Fabert et al. (2011), who argue that such

inclusivity gestures can unintentionally accentuate the stereotypes they aim to dismantle. Similarly, another participant's experience of being frequently singled out highlights an increased level of scrutiny, a finding that aligns with Fabert et al. (2011), suggesting that such practices, although aimed at promoting inclusivity, can sometimes lead to feelings of isolation and increased stress.

The participants' narratives reveal the complexity of implementing support measures that balance inclusivity with the risk of overexposure. These women's experiences highlight how visibility, when not managed carefully, can be a double-edged sword. This aligns with Girolamo and Ghali (2021), who advocate for a nuanced approach to support that recognises the fine line between encouraging participation and exacerbating pressures on underrepresented students. While the literature highlights the growing awareness among educators to support women in STEM, the challenge remains in finding the balance between providing support and avoiding overexposure. The participants' experiences, viewed through existing studies, offer insights into this complex landscape, emphasising the need for strategies that are both inclusive and mindful of minority students' individual experiences.

Additionally, when considering the research findings in the context of existing literature and Fraser's (2005, 2009) cultural dimension of justice, it becomes evident that the role of mentorship and role models in personal growth and career path decision-making. According to Dzisi et al. (2022), mentorship is crucial for promoting diversity, equity, and inclusion in STEM fields, especially for underrepresented minorities, by creating welcoming and supportive environments, enhancing training, and career development, and fostering focus through creativity, authenticity, and networking. This not only supports material equality but also addresses cultural injustices by affirming the identity and dignity of these groups, thus aligning with Fraser's emphasis on recognition to the participatory parity. Similarly, Dickens et al. (2021) highlight the transformative impact of mentors on the success of undergraduate Black women in STEM education, revealing how mentorship can correct cultural and recognition disparities, ensuring that these students are not only visible but valued and equally participative in their educational pursuits.

However, the findings from this research challenge the assumption that gender congruence between mentors and mentees is essential for effective mentorship, especially for women in STEM. Contrary to some scholars' suggestions that female mentees need female role models to thrive in male-dominated fields, the participants' experiences differ. Hernandez et al. (2020) emphasise gender in mentor-mentee relationships and suggest a need for gender-matched mentorship for undergraduate women in geoscience. Yet, the participants, all women who support gender-matched mentorship, cited male role models as pivotal influences in their STEM careers, suggesting that the mentor's gender may not be as critical as previously thought.

For instance, one participant was profoundly influenced by her stepfather, an engineer, who played a pivotal role in her decision to pursue a STEM career. Another participant found her passion for engineering during secondary school, thanks to the mentorship of a male engineering student. Similarly, another's interest in computer science was sparked by her brother, a professional in the field, while yet another participant was encouraged to explore mechanical engineering by her brother, a student in that discipline. These examples show that effective mentorship and role modeling transcend gender. The critical factors are the mentors' ability to inspire, the relevance of their guidance to the mentees' aspirations, and the creation of a nurturing environment. This insight calls for a broader understanding of mentorship in STEM, advocating for inclusivity and support systems that accommodate diverse mentor-mentee dynamics beyond traditional gender expectations.

### 5.4.2. Use of Technology in Learning

The integration and use of technology in academic activities have long been subjects of research, particularly through the lens of gender differences. The literature generally supports the notion that men may have more flexibility in using technology (Venkatesh et al., 2003), a perspective echoed by one of the participants in the study under discussion. For instance, McCoy et al. (2001) found that male students were more frequent users of computer resources, also for entertainment, and overall computer use compared to their female counterparts in a ubiquitous computing campus setting. Similarly, Marzano and Ļubkina (2019) discuss the digital gender divide, noting that socio-cultural attitudes and lower participation rates among women contribute to gender segregation in the high-tech industry. This suggests a broader narrative within the literature that aligns with the perception of greater male flexibility in technological use.

Contrary to the widely supported viewpoint of gender disparities in technology use, the findings from the current study present a different narrative. None of the female participants in a faculty of engineering reported difficulties using technological tools for academic activities, challenging the prevailing assumptions about gender and technology use and indicating a potential shift or, at least, context-dependent variability in gender interactions concerning technology use in education.

However, this observation warrants reservations when interpreting these findings. The study’s setting in a technologically intense environment may not fully represent the broader population. For example, female students from less tech-intensive STEM fields, like agricultural engineering, might not exhibit the same confidence and proficiency with digital tools. This suggests the importance of context in understanding gender differences. Literature suggests that addressing digital and gender gaps requires increased technological training across various

disciplines, especially non-STEM fields (Sáiz-Manzanares et al., 2021). This calls for cautious interpretation and further research across different academic settings to fully understand the gender-technology nexus in academic activities.

In the ever-evolving digital age, the impact of technology on minority groups has become a focal point of scholarly debate. The literature presents two opposing viewpoints on this matter. On one hand, technology is seen as a potential alienating force that exacerbates existing inequalities and isolates those on the periphery (Nishiyama et al., 2021). On the other hand, it is heralded as an inclusive tool that offers new opportunities for engagement and empowerment (Khan, 2018). This contrast accentuates the complexity of technology's role in society and its differential effects on various demographic groups.

The nuanced experiences of individuals interacting with digital platforms presented this complex interplay. Asynchronous platforms are praised for reducing gendered performance pressure, as evidenced by some participants' preference for these platforms. This finding aligns with the broader literature suggesting that asynchronous communication can level the playing field, allowing for more thoughtful participation free from the immediate pressures of live interaction (Rosen & Kelly, 2023). Similarly, the increase in confidence among women in virtual learning environments reflects a potential shift in power dynamics, offering a space less affected by cultural injustices that often permeate face-to-face settings. This is supported by Bhattacharya and Dron (2007), who note that the virtual communication’s flexibility allows participants to focus on ideas rather than personal characteristics such as race, gender, or background. Asynchronous platforms, in particular, can help reduce gendered biases and encourage more thoughtful participation compared to live interactions.

However, the digital realm is not without its drawbacks. One participant’s experience in online forums underlines the double-edged sword of digital permanence, where the pressure to perform impeccably stems from the knowledge that one's contributions will be eternally archived. This aspect of technology can reinforce anxieties related to public perception and self-presentation (Chen et al., 2023), highlighting the alienating potential of digital spaces. Furthermore, another participant’s hesitancy to engage in synchronous online forums due to a fear of appearing ignorant, and her preference to remain invisible to avoid the spotlight, illustrates how cultural biases can infiltrate and shape interactions within these spaces. Such experiences emphasise the need for a more nuanced understanding of how technology can both challenge and reinforce existing social hierarchies (Chen et al., 2023).

Moreover, the introduction of educational technologies, particularly synchronous and asynchronous digital platforms, adds an intriguing dimension to coping mechanisms for female STEM students. These technologies can mitigate challenges related to appearance and behavioural adaptation. Online interactions reduce the immediacy of physical appearance and behavioural expectations, allowing students to engage more freely without conforming to prevailing norms. This shift can significantly reduce the pressure to adapt, creating a more

inclusive educational space. However, while these technologies provide temporary relief, they do not address the root causes of cultural and gender biases in STEM fields. Reliance on digital platforms may obscure but does not dismantle these cultural injustices. Thus, while educational technologies offer valuable coping mechanisms for female STEM students, they also highlight the need for deeper systemic changes to eradicate biases and stereotypes in these disciplines.

Taken together, these findings from the field illustrate the dual nature of technology as both a liberator and a limitation, depending on the context and the individual's social positioning. The inclusion of these personal narratives in the discussion enriches our understanding of the theoretical debates in the literature, providing concrete examples of how technology's impact on minorities is multifaceted and deeply intertwined with broader societal structures and cultural norms.

## 5.5. Political Dimension of Social Justice

### 5.5.1. Support Systems and Empowerment

In the context of gender policies in STEM, Fraser (2005, 2009) highlights how policies are not just about the distribution of resources or recognition of diversity but also fundamentally about representation and participation. This dimension stresses the importance of giving voice to underrepresented groups, like women in STEM fields, enabling them to participate fully in decision-making processes that affect their lives. This approach is transformative because it doesn't just aim to amend disparities but also involves restructuring the mechanisms of policy formulation to ensure inclusive and equitable participation.

The literature is consistent with a concern regarding the gap between the formulation of gender policies in STEM fields and their tangible impacts, particularly when examining African contexts. While the literature unanimously acknowledges the importance of policies aimed at nurturing and protecting minorities, such as women in STEM fields, it also highlights the systematic inefficiencies in implementing these policies across the institutions. For instance, in South African universities, gender policies and initiatives designed to increase the inclusion of African women in STEM fields are not seen as necessarily transforming the STEM environment. Instead, they are viewed as reforms that make adjustments to the existing system, rather than reframing it entirely to address deep-rooted biases or systemic inequalities. This situation highlights the challenges faced due to racial and gendered identities and advocates for strategic interventions to pull apart oppressive ideologies (Mkhize, 2022). Similarly, the experiences of black South African female doctoral students in STEM reveal how intersectional oppressions of race, gender, and class negatively affect their progression and retention,

emphasising the need for comprehensive policies that address these multi-dimensional barriers (Idahosa & Mkhize, 2021).

Furthermore, gender-responsive STEM education policies in contexts like Uganda are highlighted as essential for enhancing women's achievement in STEM fields to drive socio-economic transformation effectively (Okwakol et al., 2022). This literature points to a critical need for policies that not only aim to increase female participation in STEM fields but also ensure these policies are effectively implemented to create a transformative impact on the individuals they are designed to support.

In the context of UEM's Faculty of Engineering, initiatives are in place to support female STEM students. The engineering faculty, in collaboration with Mozal Aluminium, a well known industrial company in Mozambique, offers preparatory courses for entrance exams that students must pass during the application process for engineering courses. Subsequently, women who are admitted to engineering courses have the opportunity to receive scholarships specifically designed for women in engineering, financed by this industrial company. Furthermore, other Mozambican companies in Maputo have provided early exposure to the STEM professional field for women still in secondary education by offering short courses in technical areas. Half of the participants in this study had access to these courses while still in secondary education, highlighting the growing efforts to attract women to the STEM field.

The findings at UEM show that despite the existence of gender-centric policies, like UEM Strategic Plan 2018-2028 (UEM, 2017) and the UEM Gender Policy 2020-2030 (UEM, 2019), and ongoing programmes like those mentioned above, students reported a lack of personal evidence regarding the impact of these policies on their lives. Interestingly, the paradox of perception versus reality is evident in the fact that four out of the six female engineering students surveyed are beneficiaries of scholarships specifically aimed at women, suggesting that, while they may lack formal awareness of the policies, they are indeed directly benefiting from them. This discrepancy accentuates a potential area for improvement in communication and awareness strategies regarding policy impacts and availability.

Another key aspect is the representation and voice of minorities, specifically women within the STEM school environment. Although the formally approved documents (UEM Strategic Plan 2018-2028 and UEM Gender Policy 2020-2030) clearly state that women have the right to speak and be heard, the experiences reported by the participants of this study do not encourage speaking out in defence of their rights as minorities. Nor does it encourage participation in groups that influence policy changes within their universities, such as student associations. According to the findings, almost all participants were unaware of any women belonging to these groups. Furthermore, they view with apprehension the fact that they feel they do not have a space where they can express themselves without fear of exacerbating their minority status.

Furthermore, although the participants acknowledge the positive impact of having scholarships, they do not exhibit signs of feeling empowered as a minority group. This highlights a crucial

gap in the design and implementation of gender policies and scholarship programmes, which, while providing resource benefits, may fail to foster a sense of empowerment and amplify the voices of the beneficiaries. To address this, policies and programmes should be designed not only to provide resource benefits but also to incorporate elements that empower the recipients and enhance their visibility and voice within the STEM community. This approach could help bridge the gap between policy objectives and the lived experiences of minority groups, ensuring that the benefits of such initiatives are both tangible and transformative, fostering a more inclusive and equitable environment for all.

These findings thus reveal a critical need for a more nuanced understanding and evaluation of policy implementation strategies. They underscore the importance of not only crafting policies with noble intentions but also ensuring that these policies translate into meaningful, tangible outcomes for the intended beneficiaries. As the literature and the case of UEM show, bridging the gap between policy formulation and its implementation could significantly enhance the efficacy of gender policies in STEM fields, thereby fostering a more inclusive and equitable academic and professional environment for women in STEM.

### 5.5.2. Use of Technology to Shape Perception and Awareness

The study highlights a notable disparity in the awareness and actual application of policies designed to aid women in the field of engineering. It pinpoints the issue as not just creating these policies but also effectively communicating their existence and objectives to those they are meant to benefit. Given that educational technologies are seamlessly embedded in the teaching and learning process, there's a compelling argument for utilising these platforms intentionally to integrate features that aid in spreading and executing policies aimed at supporting minorities in academia (O'Byrne, 2019), with a special focus on women in the context of this study. This strategy suggests a shift towards embedding policy awareness and engagement directly into the educational tools and environments where potential beneficiaries and their peers are already active, thereby improving both the reach and impact of these policies (Ackermann et al., 2009).

Moreover, the study sheds light on the feelings of marginalisation among women in engineering, who often feel they lack a platform to express themselves without exacerbating their status as minorities. However, the introduction of educational technologies appears to offer a promising solution. When discussions shifted to the realm of educational technologies, participants expressed a positive attitude towards using these platforms as neutral spaces for expression (Khan, 2018). Online forums, particularly those designed for women to discuss gender-specific concerns, are seen as valuable resources. These platforms can serve as safe spaces where women can voice their experiences and challenges without fear of backlash from the academic community (Khan, 2018).

Another significant aspect revealed by the study is the participants' expressed need for female role models and mentorship within the academic environment regardless of the fact that they have benefitted from male role models' mentorship. Many participants reported a lack of awareness of women engineers in significant positions that could amplify women's voices within the community (Casad et al., 2020; Owuondo, 2023), such as roles within the student council. The suggestion to create online pages showcasing the profiles of prominent women in engineering, like the Deputy Director for Research in the Faculty of Engineering at UEM, highlights a crucial strategy for enhancing women's representation and visibility. Such online resources can significantly impact women students' journeys within the faculty, providing them with tangible role models and mentors who exemplify the possibilities for success and leadership in engineering. Showcasing these women not only serves to inspire and guide but also reinforces the message that women belong and can excel in engineering fields, thereby contributing to a more inclusive and supportive academic environment for women in STEM (García-Holgado et al., 2020).

This positive inclination towards educational technologies stresses the potential for these tools to empower women in engineering. By providing spaces where their voices can be heard and valued, educational technologies can contribute to a more inclusive and supportive environment for women in STEM fields. This approach not only addresses the immediate need for spaces where women can express themselves freely but also aligns with broader efforts to implement policies that genuinely support women in engineering, thereby working towards closing the gap between policy formulation and implementation.

## 5.6. Conclusion

This discussion has explored the multifaceted role of educational technologies in fostering women's inclusion in STEM at UEM, framed by Fraser’s concept of participatory parity. Through the economic, cultural, and political dimensions, the chapter highlighted both the potential of EdTech to mitigate barriers and the ongoing challenges faced by female students. Economic injustices such as limited access to technology, cultural stereotypes, and inadequate policy awareness, were critically examined, demonstrating how EdTech can offer both practical solutions and platforms for empowerment. While technology presents a promising path for inclusion, the findings underscore that it must be integrated with systemic policy changes, mentorship, and institutional support to create lasting impact. As the discussion illustrates, educational technologies can serve as vital tools in addressing gender imbalances, but they must be part of broader, more comprehensive efforts to ensure that women in STEM are not only represented but fully included and empowered in academic environments.

# 6. Chapter 6: Conclusion

## 6.1. Introduction

This study aimed to understand the role of EdTech in achieving participatory parity for women studying STEM in the UEM context. It suggests EdTech could play a crucial role in fostering women's participation. The findings and contributions of this study interact across three key dimensions—economic, cultural, and political—framed by Nancy Fraser's theory of social justice. This approach not only addresses the injustices faced by women but also points to relevant opportunities for improvement in the structure of STEM education in general and at UEM in particular.

## 6.2. Towards "Participatory Parity": How Can the Use of Educational Technology be Leveraged to Increase Women's Inclusion in STEM Fields?

The study demonstrates how EdTech facilitates a more inclusive learning environment by addressing economic disparities. For women, who often balance academic pursuits with disproportionate domestic responsibilities compared to men, technology's role transcends convenience, representing significant economic gains. The flexibility of digital learning platforms allows for better time management, crucial for women in engineering who navigate academic, domestic, and, possibly, professional duties. Additionally, the shift towards digital resources, reducing the need for transportation and printing, directly translates into financial savings. These changes are not merely about redistributing resources but fundamentally transforming the economic conditions that often hinder women's full participation in STEM education.

Unexpected outcomes of my research included several notable findings. All participants received support and financial assistance from their families and the educational system, which was not anticipated by the literature review. It was unexpected for the participants to feel heard, as, in STEM, they don't usually talk outside specific subjects, and the disciplines themselves do not encourage open discussions. Additionally, the use of the "River of Life" technique revealed an unexpected openness among the participants. Despite being accustomed to more impersonal methods, like filling out surveys, the women engaged deeply and shared their experiences in a way that was both surprising and revealing.

Culturally, the study highlights the transformative potential of EdTech in creating a more equitable space for women. The digital learning environment diminishes the immediacy of physical appearance and behavioral expectations. This reduction in pressure to conform to prevailing norms fosters a more inclusive and less judgmental educational space. Asynchronous communication platforms further level the playing field, allowing for thoughtful participation

free from the immediate pressures of live interaction. Such environments can shift interpersonal interactions, offering spaces less influenced by the cultural injustices that often may dominate face-to-face settings.

Politically, the study points to a gap among female students at UEM in the awareness and application of policies designed to support women in engineering. Educational technologies offer a unique avenue not only to disseminate information about these policies but also to bridge the awareness gap effectively. The study suggests using digital platforms to highlight women's achievements and roles in STEM fields, thereby enhancing their voices, visibility and representation. Additionally, online forums and spaces dedicated to discussing gender-specific concerns provide these marginalised groups with a platform to express themselves, potentially democratising the discourse in STEM education.

The findings of this study on the inclusion of women in STEM through EdTech at UEM reveal a nuanced interplay between the economic, cultural, and political dimensions that not only overlap but also complement each other to foster an environment conducive to participatory parity: it is necessary to have all these three dimensions mutually intertwined, not just one or two of them. The economic benefits of technology, such as time and cost savings, create a foundation upon which women can more feasibly engage in STEM education, addressing immediate barriers to access and participation. This economic empowerment is intrinsically linked to the cultural dimension, where the digital environment offers a space less inclined to traditional gender biases and expectations, such as physical strength and male behaviour adoption, allowing women to express their intellect and contribute authentically. Therefore, using EdTech as an equaliser in terms of an environment with fewer traditional gender biases further intersects with the political dimension in the sense that the digital places give everyone the same starting point.This phenomenon opens up the opportunity for increased visibility and acknowledgement of women's contributions, and may lead to increased awareness of supportive policies and practices that amplify women’s voices.

The combined effect of Fraser’s three dimensions in a digital learning environment leads to increased participatory parity not only by reducing traditional barriers to women's participation in STEM but also by actively constructing a new, equitable space for engagement. The potential of EdTech as a transformative tool, and as the ultimate goal for achieving social justice is, thus, illustrated.

## 6.3. Implications of This Research

This research highlights the transformative potential of EdTech in promoting gender parity in STEM education by enriching theoretical frameworks and offering practical, policy, and social implications. By applying Nancy Fraser's social justice framework, it calls for further interdisciplinary research that explores how EdTech can overcome specific barriers faced by

women. Practically, it emphasises integrating digital platforms to create inclusive and flexible learning environments, offering strategies like providing access to digital resources and fostering online communities. Policy-wise, it advocates for institutional and governmental investment in EdTech to enhance digital infrastructure, support teacher training, and promote gender-inclusive practices. Socially, it suggests a cultural shift towards inclusivity and diversity in STEM, challenging traditional gender norms and biases.

## 6.4. Recommendations

### 6.4.1. University Management

- Implement Comprehensive Policy Awareness Campaigns: Regularly disseminate information about existing support policies and initiatives for women in STEM through digital channels to ensure that all students are aware and can take advantage of them.
- Invest in Digital Infrastructure: Ensure that all students have access to reliable internet and modern digital learning tools to facilitate equitable participation in STEM fields.
- Monitor and Evaluate Technology Use: Continuously assess the effectiveness of educational technologies in promoting inclusivity and make adjustments based on feedback from women in STEM courses.
- Expand Online Learning Options: Develop and expand online resources and programs in STEM to accommodate diverse learning needs and schedules, particularly for students balancing multiple responsibilities.
- Create Dedicated Support Services: Establish a support centre specifically for women in STEM to provide mentoring, counselling, and career guidance services.
- Development of a Centralised Digital Platform: UEM should develop and implement a centralised digital platform that disseminates information about policies supporting women in engineering, and highlights the achievements and challenges faced by women in STEM fields
- Sponsorship of Annual Symposiums or Workshops: The university could sponsor annual symposiums or workshops focused on gender equity in STEM, leveraging technology to include virtual participants.
- Training in Gender-Sensitive Pedagogy: Training should be provided to ensure that lecturers are equipped to manage and facilitate discussions in online forums that respect and value diverse perspectives, fostering an environment where all students feel equally empowered to express and develop their academic interests.

### 6.4.2. Lecturers

- Incorporate Inclusive Teaching Practices: Use educational technologies to create diverse and inclusive curriculum materials that cater to a variety of learning styles and backgrounds.
- Promote Asynchronous Learning: Provide more asynchronous learning opportunities to allow students to engage with materials at their own pace and time, reducing the pressure of synchronous schedules.
- Facilitate Online Discussion Forums: Regularly moderate and participate in online forums dedicated to STEM subjects, encouraging the participation of female students and ensuring a respectful and supportive environment.
- Highlight Women's Achievements in STEM: Actively integrate case studies, examples, and contributions of women in STEM fields into lectures to enhance visibility and representation.
- Engage in Continuous Training: Participate in training programmes that focus on technologically equipped teaching methods and gender-sensitive pedagogy to better manage diverse classrooms and facilitate inclusive discussions.

### 6.4.3. Students

- Leverage University Resources: Actively seek out and use the digital resources and support services provided by the university to enhance learning and career opportunities in STEM.
- Participate in Online Forums and Networks: Engage with online communities and forums dedicated to STEM, which can provide support, networking opportunities, and a platform for discussing gender-specific concerns.
- Utilize Asynchronous Communication Tools: Take advantage of asynchronous communication tools to contribute thoughtfully to discussions and projects at your own pace, balancing academic and personal responsibilities.
- Advocate for Your Needs: Communicate your needs and suggestions for improving educational technology and support systems to university administration and lecturers.
- Support Peer Learning: Collaborate with peers through digital platforms to create a supportive learning network, sharing resources, knowledge, and experiences to enhance collective success in STEM fields.

## 6.5. Limitations of the Study

Despite the meticulous nature of the study, certain limitations were present. Conducting three in-depth interviews per participant limited the number of participants, as they were students with heavy schedules and domestic chores. This limitation, however, allowed for deeper engagement, moving beyond superficial insights. My personal experiences as a woman in STEM posed a potential bias, which was addressed with transparency, but also created an affirming connection with participants. Despite these challenges, the study concluded that Educational Technology has the potential to facilitate the inclusion of women in STEM education, offering tools and platforms that can help bridge the gap and create more equitable learning environments.

## 6.6. Future Work

The recent study highlighted the transformative potential of educational technologies for women in STEM fields. To expand the reach of these findings, a future research project involving an intervention through action research is proposed. This approach would allow the practical implementation of educational technologies in a focused manner, using the elements identified in the current study in light of Fraser's social justice dimensions. The proposed intervention would not only facilitate the application of technologies in real-world contexts but also enable the direct measurement of their impact on promoting equitable participation of women in STEM. This practical and measurable focus would offer a clear pathway to assessing how technology-based interventions could effectively contribute to achieving participatory parity in STEM fields.

Furthermore, it is important to emphasise that, while many studies have been applied to Fraser's theories, few address the impact of technology on participatory parity, and even fewer focus on women in STEM. As seen in the discussion and conclusion of this study, our approach has revealed numerous possibilities that are not typically explored in the field of technology. Additionally, the unique circumstances faced by women in STEM in resource-constrained countries suggest that Fraser's ideas could be further developed with a focus on the Global South. This deepening of Fraser's concepts could provide a richer understanding of how to achieve participatory parity for women in these regions through targeted technological interventions. In light of the recommendations from this research, there emerges the need for the creation of a specialised research unit that will follow up on the recommendation using an evidence-based approach that will help in the advancement of women in STEM fields towards participatory parity.

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# Appendix A - Ethical Clearance Letter

**SCHOOL OF EDUCATION**

**Dr. Joanne Hardman**
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Deputy Director School of Education

University of Cape Town, Private Bag X3, Rondebosch, 7701
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**EDNREC20230405**

Leila Omar
OMRLEI001

20 April 2023

**Re Ethical clearance**

I am pleased to inform you that ethical clearance has been granted by the School of Education Ethics Review Committee of the Faculty of Humanities for your academic project: The role of Educational Technology as an enabler for women's inclusion in the STEM field. Case study: Eduardo Mondlane University. We wish you all the best with your research

Regards

ASSOCIATE PROFESSOR JOANNE HARDMAN

## Appendix B - Information Sheet for Students

Dear Miss//Mrs_____

**Research title: The role of Educational Technology as an enabler for women's inclusion in the STEM field: Case study: Eduardo Mondlane University**

I, Leila Omar, am a researcher based at the School of Education at the University of Cape Town and a lecturer at Eduardo Mondlane University (UEM). I would like to request your permission to conduct my research on the role of Educational Technology as an enabler for women's inclusion in the STEM field at UEM with your participation. My research aims at exploring how Educational Technology can be an enabling factor to achieve social justice for minority groups, in the university context of female engineering students in undergraduate courses. There is a growing body of research on the use of Educational Technology to promote more inclusive education. However, in the Mozambican Higher Education context, research about Educational Technology as a tool for fostering women's inclusion, particularly in the STEM Education field, is scarce.

Data will be gathered through three scheduled interviews, each lasting 60 minutes and spaced by two to three weeks. This allows for the potential for context inquiry and incremental reconstruction of the participant's experience over time. The interviews will be recorded on audio, transcribed, and returned to the participants for validation and ethical consideration.

Your participation is entirely voluntary, and your confidentiality is assured. You will be assigned a pseudonym (a different identity), and pseudonyms will be used for all participants in the writing up of the research. Unless with your clear written permission, the audio recordings will not be revealed during the research or in the future. You may withdraw your consent to participate in the study at any time.

Please fill in the slip below to indicate your consent for the research. You are welcome to ask any questions regarding this research by telephone or email:
leila.a.omar@uem.mz/leila.agyomar@gmail.com or (+258) 820119310.

Yours sincerely,

Leila Omar

## Appendix C - Informed Consent Form for Students

# PARTICIPANTS CONSENT FORM

**Research title: Factors motivating lecturers' uptake of blended learning at Eduardo Mondlane University**

| | |
|---|---|
| I agree to participate in this study. | YES ☐ NO ☐ |
| I understand why I am participating in this research. | YES ☐ NO ☐ |
| I consent to be interviewed. | YES ☐ NO ☐ |
| I consent that my interviews will be audio recorded | YES ☐ NO ☐ |
| My concerns and questions about the project have been addressed. | YES ☐ NO ☐ |
| **Confidentiality**<br><br>I acknowledge that the research project will de-identify me and my department/ course and redact ("delete") details to obscure my identity. | YES ☐ NO ☐ |
| **Identification**<br>I wish to be identified in the following way within research outputs:<br>If you would like to choose your own pseudonym, please indicate below:<br><br>_____ | A preferred pseudonym ☐<br><br>The researchers' choice of pseudonym ☐ |
| I agree to be directly quoted in the research in line with my preference above. | YES ☐ NO ☐ |
| I agree for artefacts created by me during sessions to be used in line with my preference above. | YES ☐ NO ☐ |
| **Research publication**<br>I am aware that the research will be published in academic journals. Researchers will be able to publish from this data, individually or with others. | YES ☐ NO ☐ |
| **Possible Harm**<br>I have been informed that there is little or no risk related to this study. | Initial: |

| | |
|---|---|
| I understand that I am participating voluntarily and I may withdraw at any time without prejudice. (I understand I am free to leave the study at any time.) | Initial: |
| I have not been offered any reimbursement for participating in this study. | Initial: |

| **Researcher:** | **Participant** |
|---|---|
| Name: ……… | Name: ……... |
| Signature:…… …… | Signature:…… ……. |
| Date:…… …… | Date:…… ……. |

# Appendix D - Interview One Guide: Focused Life History with "River of Life"

**1. Preparation**

- Verify the interview date, time, and location with the participant the day before.
- Ensure all necessary materials are ready: consent forms, "River of Life" examples, paper, markers, and pens for in-person interviews.
- Prepare a printed or digital copy of the interview guide with questions.
- Arrange seating to create a comfortable and conversational environment.
- Ensure all materials (paper, markers, etc.) are easily accessible.

**2. Conducting the Interview**

**Introduction:**

- Greet the participant and thank them for their participation.
- Review the consent form, ensuring the participant understands and signs it.
- Reassure the participant about confidentiality and anonymity.
- Explain the interview's purpose and structure.

**Step 1: Warm-Up:**

- Briefly introduce yourself and the research project.
- Ask the participant to introduce themselves and share a bit about their background.

**Step 2: River of Life Activity:**

- Explain the "River of Life" activity: Participants will draw a timeline of significant life events that led them to engineering.
- Show examples of "River of Life" illustrations to provide a clear understanding.
- Provide paper and markers (for in-person).
- Give participants 20-25 minutes to create their "River of Life."
- Allow participants to ask questions or seek clarification during the activity.

**Step 3: Life History Interview:**

- Begin the interview by discussing the "River of Life" timeline.
- Use the following interview questions to guide the discussion

**Interview Questions:**

1. What is your academic department?
2. What engineering program are you currently attending?
3. In which academic semester are you? And how much time is left to finish the program?
4. Can you start by telling me about your childhood and upbringing?
5. What motivated you to study engineering?
6. When did your interest in STEM begin?
7. What motivates and drives you to pursue your education in engineering?
8. Have you had any role models or mentors who have supported you in your academic journey?
9. How do you see your future career in engineering?
10. Did your family support you when you decided to take this course?
11. What was it like when you started attending classes? What were your first impressions?
12. Have you faced any challenges or barriers in pursuing your engineering education?
13. How do you feel about your current academic progress and performance?
14. How do you currently use educational technologies in your engineering studies? For example, do you use LMS forums (to read, ask questions, and interact with peers)?
15. Do you use online textbooks or other digital resources in your learning?
16. Have you ever felt excluded or marginalized in the use of educational technologies in engineering classes? If so, can you describe the experience? And how have you overcome them?
17. Are there any specific educational technologies that you have found particularly helpful in your engineering studies? If so, can you describe them?

**Step 4: Closing the Interview:**

- Summarize the main points discussed and thank the participant for their time and insights.
- Inform the participant about the next steps, including the timing of the next interview.
- Reiterate confidentiality and the process for reviewing and verifying interview transcripts.

**4. Post-Interview**

- Send a thank-you email to the participant, reiterating appreciation for their time and insights.
- Provide information about the timeline for the next interview and any additional steps.

# Appendix E - Interview Two  Guide: Focused on Current Experiences Details

**1. Preparation**

- Verify the interview date, time, and location with the participant the day before.
- Ensure all necessary materials are ready:
    - Consent forms
    - Digital tools and materials for online interviews
- Prepare a printed or digital copy of the interview guide with questions.
- Arrange seating to create a comfortable and conversational environment.
- Ensure all materials (digital or physical) are easily accessible.

**2. Conducting the Interview**

**Introduction:**

- Greet the participant and thank them for their participation.
- Review the consent form, ensuring the participant understands and signs it (for online, obtain verbal consent and send a digital consent form if needed).
- Reassure the participant about confidentiality and anonymity.
- Explain the interview's purpose and structure.

**Step 1: Warm-Up:**

- Briefly introduce yourself and the research project.
- Ask the participant to share any reflections or thoughts they had since the first interview.

**Step 2: Focused Experience Details Interview:**

- Begin the interview by revisiting any key points from the first interview that may need clarification or further exploration.
- Use the following interview questions to guide the discussion:

**Interview Questions:**

**Economic Dimension:**

1. What challenges have you faced as a female engineering student, particularly in terms of accessing resources and opportunities?
2. In your opinion, what are the most important resources and opportunities that female engineering students need to succeed in their studies?

3. How can technology be used to ensure that everyone has the same access to educational resources and opportunities? Did the LMS tools help with this?
4. In what ways do you feel that economic factors, such as financial resources and funding opportunities, impact the learning experience of female students in engineering courses?
5. Have you seen any successful initiatives or practices in your classes that have helped female students who face financial challenges and made the classroom more inclusive for everyone? If so, can you describe them?

**Cultural Dimension:**

1. How do you feel about your identity as a female engineering student? Do you feel that it is recognized and respected within your academic community?
2. Have you ever felt excluded or marginalized in your engineering studies because of your gender? If so, can you describe the experience?
3. Have you experienced any cultural barriers or challenges during classroom activities in your engineering courses, such as biases or stereotypes that have impacted your ability to participate or learn?
4. In your opinion, what are some of the cultural factors that contribute to an environment where female engineering students' identities and experiences are not recognized or respected?
5. What steps do you think could be taken to address these cultural factors and create a more inclusive environment for female engineering students?
6. In your opinion, what role can lecturers play in creating a more inclusive and respectful environment for female engineering students?
7. Have you ever participated in any initiatives or programs designed to support female identity? If so, can you describe your experience?
8. How can educational technologies be used to create a more inclusive and respectful environment for female engineering students? Did the LMS tools help with this?

**Political Dimension:**

1. How do you feel about the representation and visibility of female engineering students in your courses? Do you feel that it is adequate, or are there areas where it could be improved?
2. Do you feel that the way engineering classes are taught and the environment they create can be fair to female students in terms of how faculty's rules and regulations are designed and enforced?
3. Do you feel that the current representation of women in the engineering industry impacts your career aspirations? Why or why not?
4. Do you know any women that belong to any student representation group? Are you willing to join any student representation group?

5. In your opinion, what role can lecturers play in increasing the representation and visibility of female engineering students in courses?
6. Are there any specific educational technologies that you have found particularly helpful to increase the representation and visibility of female engineering students in courses? If so, can you describe them? Did the LMS tools help with this?

**Step 3: Closing the Interview:**

- Summarize the main points discussed and thank the participant for their time and insights.
- Inform the participant about the next steps, including the timing of the next interview.
- Reiterate confidentiality and the process for reviewing and verifying interview transcripts.

**3. Post-Interview**

- Send a thank-you email to the participant, reiterating appreciation for their time and insights.
- Provide information about the timeline for the next interview and any additional steps.

# Appendix I - Interview Three  Guide: Reflection on Interviews One and Two

**1. Preparation**

- Verify the interview date, time, and location with the participant the day before.
- Ensure all necessary materials are ready:
    - Consent forms
    - Digital tools and materials for online interviews
- Prepare a printed or digital copy of the interview guide with questions.
- Arrange seating to create a comfortable and conversational environment.
- Ensure all materials are easily accessible.

**2. Conducting the Interview**

**Introduction:**

- Greet the participant and thank them for their participation.
- Review the consent form, ensuring the participant understands and signs it.
- Reassure the participant about confidentiality and anonymity.
- Explain the interview's purpose and structure.

**Step 1: Warm-Up:**

- Briefly introduce yourself and the research project.
- Ask the participant to share any reflections or thoughts they had since the second interview.

**Step 2: Reflection Activity:**

- Explain the purpose of this interview is to reflect on and deepen the understanding of the topics discussed in the previous interviews.
- Provide any necessary materials (if conducting any visual or mapping activities).

**Step 3: Reflection Interview:**

- Begin the interview by presenting the findings from the first two interviews
- Discuss the participant's reflections on the first two interviews.
- Use the following interview questions to guide the discussion.

**Interview Questions:**

1. How do you feel about the preliminary findings, and what aspects do you think misrepresent your experience or need further details?
2. After considering the previous interviews, do you think you have gained a better understanding of the challenges women face in the field of engineering?
3. How do you think this awareness can benefit other female students in engineering?
4. Was there anything specific from the previous interviews that made you rethink or reconsider your experiences or perspectives as a woman in engineering?
5. Would you recommend that other female engineering students participate in similar discussions and interviews? Why?
6. Do you feel that your participation in this study has impacted your perspective or experiences as a female engineering student? If so, how?

**Step 4: Closing the Interview:**

- Summarize the main points discussed and thank the participant for their time and insights.
- Inform the participant about the next steps, including any final steps in the research process.
- Reiterate confidentiality and the process for reviewing and verifying interview transcripts.

**3. Post-Interview**

- Send a thank-you email to the participant, reiterating appreciation for their time and insights.
- Provide information about the timeline for the completion of the study and any additional steps.

# Appendix F - Women's Life Stories Details

To gain insights into the experiences of women within the engineering courses at UEM, a total of six participants shared their voices, each from diverse engineering courses and coming from various regions of the country, with ages ranging from 20 to 30 years. These six women, each at different stages in their academic journey, contributed to a multifaceted collection of experiences that will enhance the understanding of the impact of EdTech on the cultural, social, economic, and political dynamics within their academic environment.

Adhering to the specified interview protocol, the researcher conducted three interviews with each participant, resulting in a total of eighteen interviews. Each interview was approximately 60 minutes in duration. To fully understand the stories of each participant, the first interview of the protocol focused on understanding the journey of the participants to reach STEM education and seeing if, during this journey, they experienced any kind of social justice inside and outside of the classroom. During the interview process, the participants were able to tell their narratives through the River of Life (Bozalek & Biersteker, 2010), which technique entails the creation of visual representations of events and narratives, allowing participants to create visuals or bring objects to tell their life stories more engagingly and interactively. The participants were able to share their views and feelings about the research issue more dynamically and engagingly using this strategy. As we delve into the heart of this research, we will soon be introduced to each of our participants, whose stories are composed to shed light on the nuanced experiences of women in the field of engineering.

**Laura**

Laura, a woman in the final stretch of her graduate studies in Informatics Engineering, carries the essence of her family's legacy—one where education is not just a pursuit but a sacred duty. Her journey began in the heart of a family where love was abundant, and the world was a playground for her and her younger brother. The familial landscape shifted when her parents divorced, and Laura, alongside her mother and brother, sought support and a fresh start near her grandfather's home. Her early years were shaped by the sheltered environment of an all-girls school. This lack of diversity, although safe, inadvertently instilled a timidness in her, a barrier her mother's gentle persuasion helped her overcome as she was encouraged to forge new bonds in their neighbourhood. Her life's story took a decisive turn at the age of 10 when the carefree time spent in play gave way to a structured schedule: academic sessions in the morning, religious education post-lunch, and language lessons by the sunset. This structured approach mirrored her family's firm belief in the power of education, often summed up as a repeated directive: "You have to study, you have to study."

As Laura grew, her world expanded beyond the physical confines of her neighbourhood into the vast expanse of the digital realm: "I'd always be on my mother's computer whenever she

had it at home.... I was captivated by the digital world from an early age," she shared. The tools of educational technology became her study companions, offering her a well-arranged space for her thoughts and studies, “I use various platforms, and they are easy to interact with," she would say, appreciating the clarity they offered. However, this digital frontier was not without its challenges. Laura found that the same technology that made her daily tasks more efficient could also disperse her concentration: "It's very easy to lose attention," she confessed, acknowledging that the distractions of the digital world could diminish her learning. Despite the convenience of online forums and the scope of knowledge at her fingertips, Laura often opted to stay in the background, remaining a silent observer, keeping her questions to herself, "The more invisible I am, the better," she expressed. This hesitancy in the virtual world was not a sign of disinterest but a preference to remain an unseen participant within the learning environment, perhaps a reminiscence of her early school years.

Juggling a demanding academic routine with her duties at home, Laura navigates through her multifaceted life, weaving through her responsibilities as a student, a daughter, an older sister, and an emerging professional. Her journey doesn't follow a straight line but a 'river of life' that roves the landscapes of both traditional and digital education, shaping a unique niche for her perspectives to emerge with strength and distinction. In her student journey, marked by highs and lows, her intellect asserted itself, despite the layers of identity that often precede it. Laura's transition from a sheltered school environment to an expansive male-dominated learning environment is a testament to her resilience and commitment to learning. As she prepares to graduate, she represents the enduring spirit of minority women in STEM, poised to make her mark with the strength of her education and the depth of her experiences.

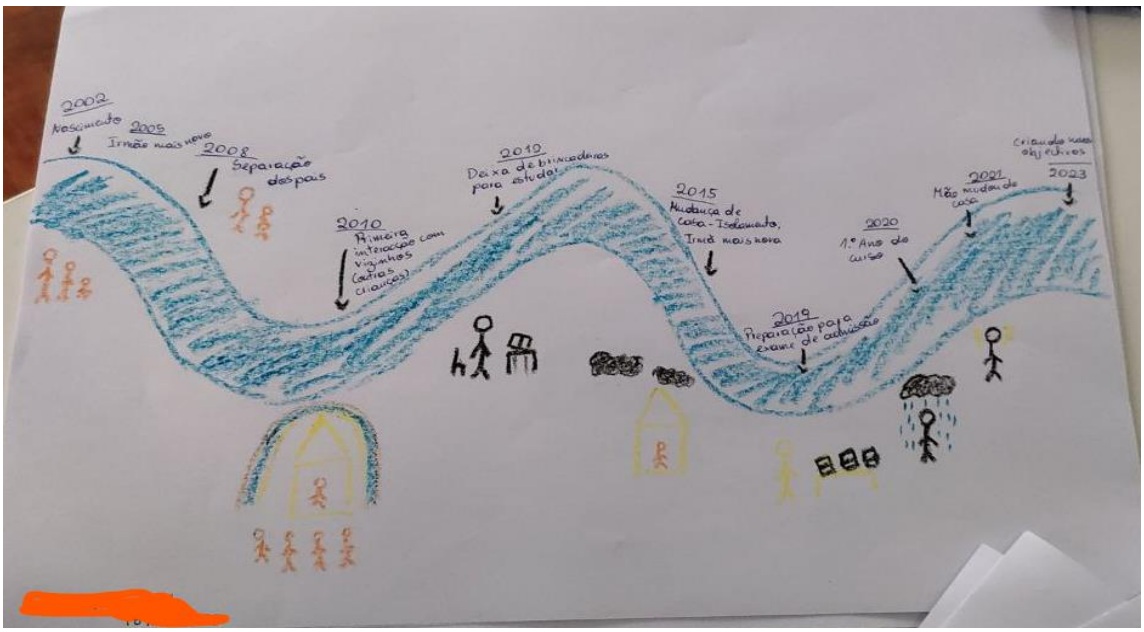


Figure 1*: Laura's River of Life*

**Sofia**

Born at the end of the 90s, Sofia is a female graduate student in Engineering at UEM, and her academic journey has been anything but ordinary. Her early years were spent in a country neighbouring Mozambique, a place she was suddenly taken away from by one of her parents. This experience led to a childhood marked by transitions and language obstacles, both of which played an important role in moulding her character and influencing her educational journey. The separation of her parents forced a move back to her grandparents, where she tackled the primary education system with grit, despite the academic challenges she faced. "I was doing well because I got good grades but not because I really understood everything that was taught at school," she shares, reflecting on the early struggles to adapt, especially with the Portuguese language. This barrier initially isolated her, with no friends in the first grade and a profound sense of exclusion. Her grandparents' unwavering support and the hiring of a tutor marked the beginning of her overcoming these difficulties. Sofia's initial difficulties in speaking Portuguese, which extended to interactions with her own family, highlight the obstacles she faced at the start. With time, her command of the language improved, along with her self-assurance, allowing her to successfully manage her school life and the complexities of engaging with others socially.

Sofia's journey through engineering education is marked by episodes of collaboration and innovation, all encouraged by the integration of EdTech. "Here have been advances. I'm able to communicate with my classmates whenever needed. For instance, in group assignments, we utilise platforms like WhatsApp and Google Docs, allowing each of us to contribute, everyone can add what they want, and all can see," she points out, shedding light on the way digital tools have fostered enhanced communication and group dynamics in her studies. Her transition from facing early obstacles in group projects to becoming a respected contributor whose insights are valued depicts her development both on a personal and academic level. "At the beginning, we used to have frequent arguments and no one was willing to listen to someone else," she remembers. Now, she is recognised as an integral part of the team, with her opinions being heard and esteemed by her peers. Her adeptness with technology also became an asset, as she often took on the role of digitising group work because she was the only one with a laptop. "I liked to digitise because I had knowledge of the entire work, even the part researched by colleagues," she states, indicating a keen understanding and involvement in the collective effort.

Sofia's academic pursuit in engineering is as much about her scholastic dedication as it is about her adept management of considerable home obligations. Tasked with caring for her elderly grandparents, she shoulders tasks typically expected of women in her household. In an interview, she highlighted the gender-based disparity, stating, "If I were not a woman, my academic performance might have been different, because I live with my grandparents who require care. My day often begins with household tasks before I can turn my attention to my studies..." For Sofia, every minute is valuable, and finding enough time to dedicate to her studies is a consistent challenge. "For me, time is precious, and currently, it's a resource I find

myself short of, as I try to juggle my university work and home duties," she admits, emphasising her need to effectively allocate what little she has to meet both her educational and familial commitments. Educational technology has been an important ally in Sofia's struggle for time. The convenience of engaging with her coursework digitally has given her the much-needed flexibility to study around her home-care duties. The digital tools for learning allow her to participate in group projects, access resources, and fulfil academic requirements without being physically present at all times, supporting her continued academic trajectory while managing her responsibilities at home.

Sofia's story is a compelling illustration of resilience and adaptability shaping a transformative educational experience. Her narrative is a blend of overcoming linguistic barriers, embracing technology as a catalyst for academic and personal development, and carving out a space in the realm of engineering where her voice is not only heard but also valued. As she progresses through her final year of graduate studies, she not only excels academically but also manages responsibilities at home. Her story serves as an inspiration to female students, proving that success in education is about the persistence of the student, just as much as it is about learning.

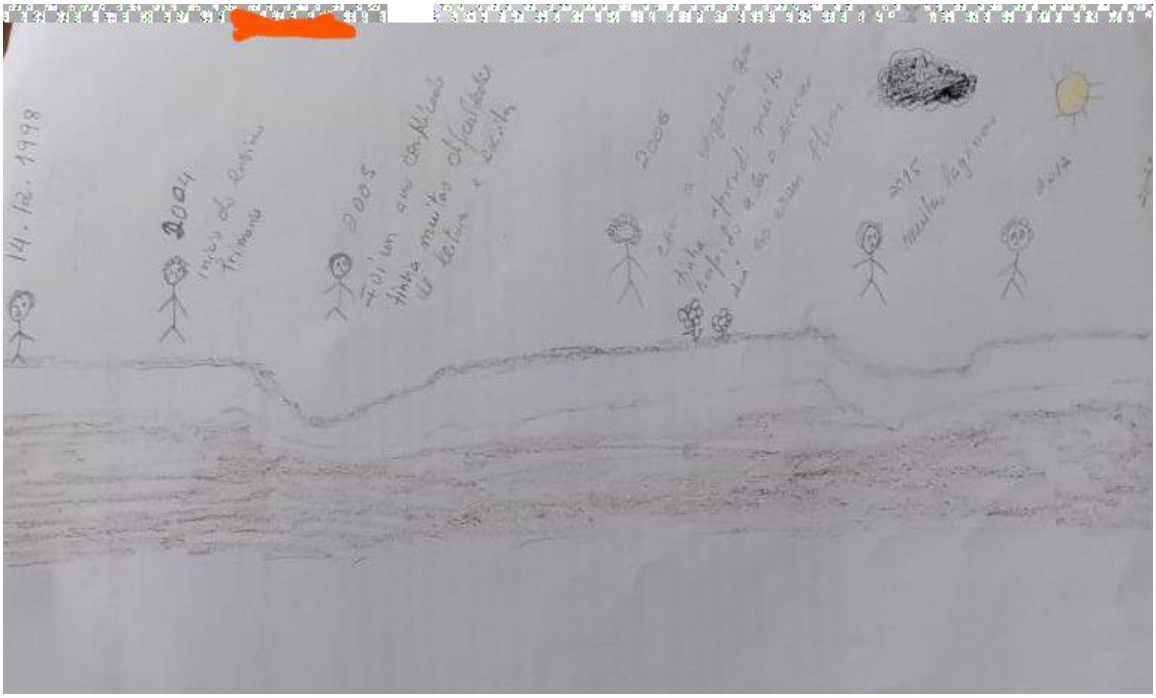


Figure 2*:Sofia's River of Life*

**Isabel**

Isabel's story traces back to the very start of her life, a moment she humorously notes as crucial for her current place in the world of engineering. Raised in a family that valued education, she faced a defining moment in 2017 when she was transferred to another secondary school in her hometown: "... I entered X secondary school, and I think that if I hadn't studied there I wouldn't have entered the engineering course," she said. It was there that her academic talents truly began to shine, culminating in her becoming the top student in her eleventh grade. This achievement led her, at age 17, to an opportune coding program specifically for girls hosted by one of the largest telephone companies in Mozambique. "It was there that I learned the basics of web programming," she reflects, "and, by the end of the week, we had created a webpage to present. That was the spark that ignited my curiosity about the tech field." Before this experience, Isabel had not decided on a career path, but the experience stimulated a desire to delve deeper into the world of engineering. Determined to pursue this newfound passion, she applied to a specific engineering course, and her first attempt did not land her a spot at her preferred university (UEM), but she was accepted at another university. The setback did not prevent her, instead, it fuelled her resolve to try again for UEM the following year, reflecting her unwavering commitment to her goals.

Isabel's journey toward a career in engineering was deeply rooted in the support and encouragement she received from her family, particularly as her interests often aligned with what was traditionally considered 'men's work' in her community. From an early age, she found joy in tasks like fixing shoes and slippers, chores that, in her community, were typically reserved for men. "I always stepped in to help my father whenever he faced troubles with the computer," she says, reflecting on the early signs of her technical aptitude and also pointing to the opportunity for contact with digital technology from an early age within the family. When it was time for Isabel to choose her path in HE, her family's firm belief in her capabilities encouraged her to pursue engineering. This decision allowed her to follow her interests and defy the gender stereotypes of her community. With her family's support, she confidently pursued her studies, firmly on the path to becoming an engineer.

Isabel's academic path in engineering has been shaped not just by her studies but by the quiet struggles she faced as a woman in a predominantly male field and due to her own innate declared shyness. Shyness was a block for her, one that often saw her keeping to herself. "Shyness was a barrier... I'm a bit less shy now than when I started my course. I used to just sit in a corner of the room, and if nobody approached me, I wouldn’t reach out either," she explained. Despite these issues, Isabel sees the role of EdTech, which she believes can be a bridge for those who are introverted. She suggests that "Technology might help because it allows people who are shy to engage more comfortably in a virtual space," indicating that digital platforms can provide a more accessible and comfortable way for students like her to participate and interact.

Isabel's narrative also touches on the gender disparities that are incorporated into her everyday experiences. She highlights a contrast in expectations around domestic duties, noting that, for her male peers, such tasks seem to be more of a choice rather than an obligation. "For us women, it's mandatory to complete our household tasks before, and then we can think about studying," she reflects. This intersection of her educational pursuits with home responsibilities tells her adeptness at maintaining a balance. "It's been really tough," she admits, acknowledging the difficulty of shifting from domestic tasks to tackling school assignments, often while still drained from the household tasks. However, technology has become an unexpected ally, enabling her to participate in classes from home intercalating with household tasks, or to review recorded lectures, thus alleviating the need for a tiring journey on public transport. Despite these challenges, Isabel feels integrated into the field of engineering, save for her "weak interaction in the classroom". Her academic progress is a journey of continuous integration, marked by the intersection of her resilience and the enabling power of technology.

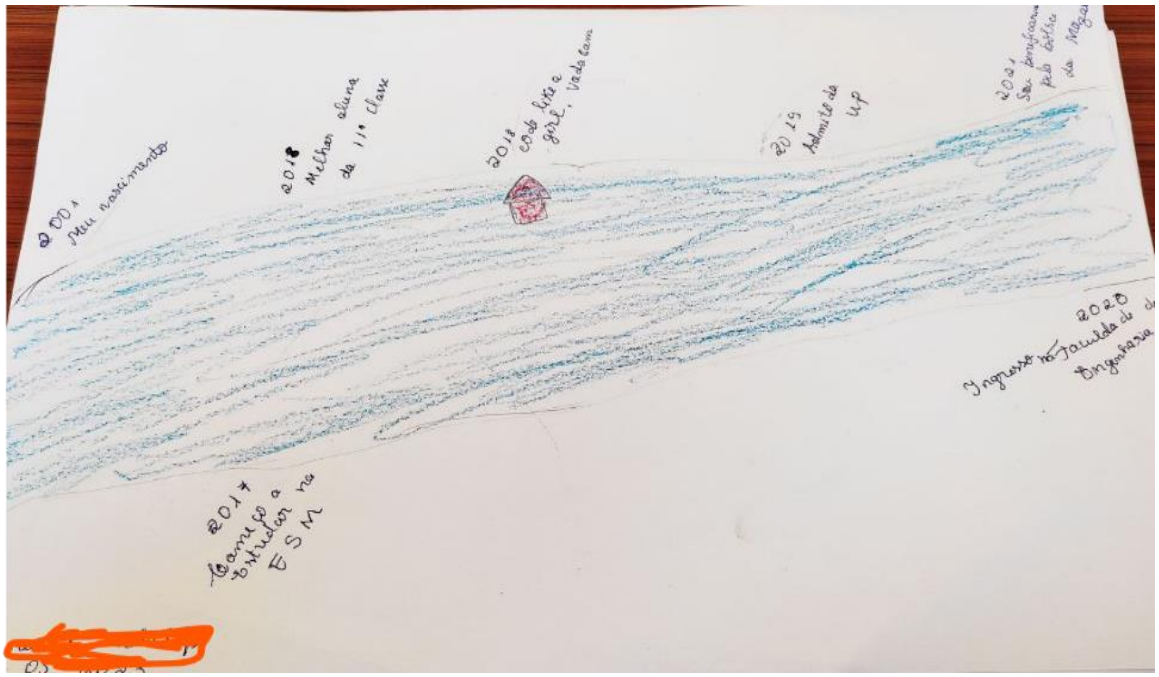


Figure 3*: Isabels River of Life*

**Denise**

Denise's journey through life began in the hectic environment of a large family, where she was one of more than six siblings. Her personal development, symbolised by the river she illustrated to depict her life, mirrors its course: beginning as a narrow stream and gradually widening over the years. This reflects her journey of physical, psychological, and intellectual growth, as she herself describes. At a tender age, by the age of eleven, Denise transitioned from the unconcerned play of childhood to the structured world of academic and domestic responsibilities. She recalls, "I had to stop playing as a child too soon because, at home, they influenced me." The memories of her childhood are filled with the sounds of a busy home, where she found herself loaded with household tasks after school, often denied the leisure of playtime in the afternoons.

Growing up in a large family, Denise found herself part of an assumed yet traditional division of labour. The household duties naturally fell to the girls, herself included, as a matter of course, while her brothers were expected to lend a hand in the carpentry business run by their father. She reflects, "When my brothers wanted to help, they did, but it wasn't their responsibility. They helped but not with tasks typically known as women's tasks. They help with cleaning and carpentry," she recalls.

Denise's fascination with engineering took root in high school, sparked by a science fair where she not only presented a homemade radio she had constructed but also witnessed an array of scientific projects from her peers. This event deepened her affinity for the precise nature of the exact sciences, which eventually guided her academic choices. "I chose the engineering course because I liked the exact sciences," she explains. Additionally, her family environment is also another factor that, even if indirectly, may have driven her towards the science field, as one of her brothers was already attending an engineering course at UEM, and a sister was immersed in a technical high school programme specialising in the hydraulics field.

Denise guides her role as a woman in a technical field with a sense of complexity. She reports feeling respected by her male peers, noting a sense of brotherliness that sometimes comes with added benefits, what she considers a privilege. When collaborating on projects, the responsibilities are distributed equitably, usually aligning with each member's domain or interests. However, she remembers a time during her first year when she was assigned only the simpler segments of a group presentation, a decision she believes stemmed from the unpredictability of working within a newly formed team dynamic.

Denise views her academic journey with a blend of satisfaction and introspection. While she acknowledges her achievements, she also recognises areas for improvement, particularly in classroom engagement. "The greatest limitation I face, which continues even now, is speaking up in class. I'm often silent, hesitant to speak even when I know the answer," she admits. This reluctance arises from a fear that her peers and professors might not grasp her explanations. Denise notes a slight improvement in her communication with the adoption of digital tools like

WhatsApp, which offered her a platform to articulate her thoughts with less pressure. However, she concedes that her participation remained limited, saying, "WhatsApp gave me a chance to express myself a bit more, but I often chose to remain quiet."

The incorporation of technology into Denise's education has had both beneficial and challenging aspects. It has widened her access to knowledge but also presented obstacles, particularly during the COVID-19 pandemic when in-person, technical demonstrations were not possible — a vital component of her engineering studies. However, she is grateful for the digital tools that have enriched her ability to communicate and dive deeper into her coursework. Now in her fourth year of Engineering, Denise's story is characterised by her ability to persevere, adapt, and constantly seek equilibrium between conventional methods and new technologies, her domestic responsibilities, and her academic goal.

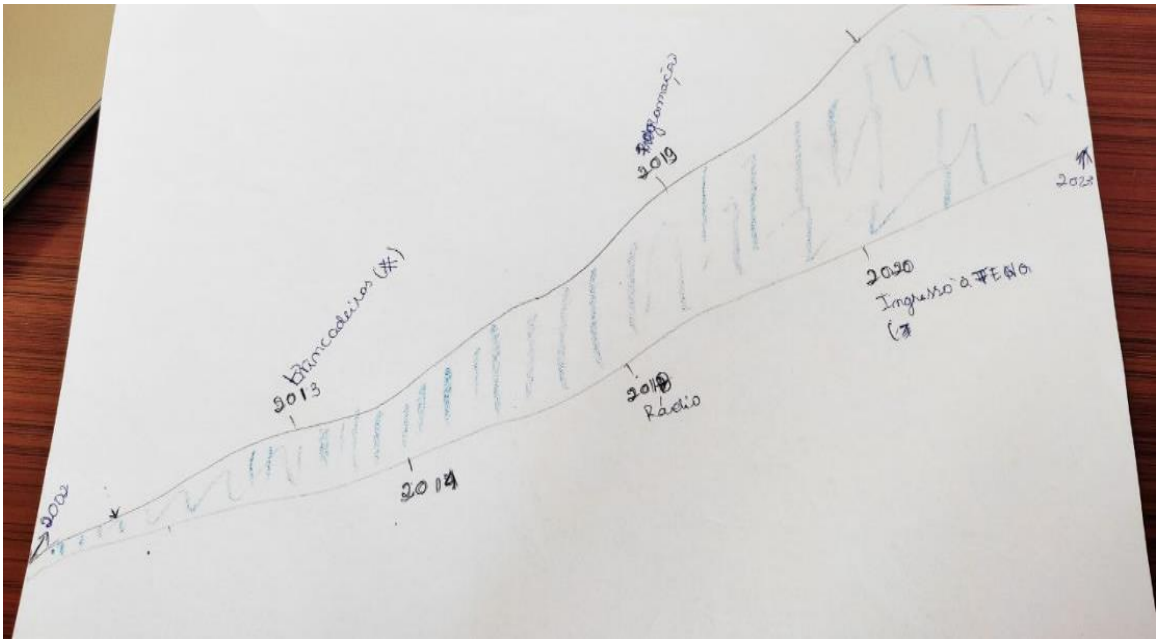


Figure 4*: Denises River of Life*

**Maura**

Maura's life journey was deeply influenced by her father's mentorship, which acted as a guiding light, setting the stage for her personal and educational development. Her father's words served not just as advice but as directives towards independence and achievement. "He is my best friend," she states, her tone reflecting the deep respect and importance she assigns to her familial ties and education. Even when societal norms suggested there were topics "girl-specific" subjects as off-limits for father-daughter discussions, Maura always felt compelled to confide in him, relying on his discernment and encouragement.

Her academic life took a distinct turn when she entered secondary school at the age of 13. This period of adolescence came with its own set of challenges, among them struggles with self-esteem, particularly during her eighth- and ninth-grade years. She shares an honest glimpse into those times, "I thought I was ugly, too dark," giving voice to the internal conflicts reflecting on a period marked by self-doubt and the external pressures of societal beauty standards that weighed heavily on her young shoulders during her early teens. However, by the time she reached the eleventh grade she had overcome these insecurities, recognising them as childhood misconceptions. Maura's narrative also touches on the delicate subject of adolescent sexuality, shaped by her mother's guidance to abstain from sexual relationships until reaching the age of majority. This advice resonated deeply with her, becoming interlaced with her aspirations and academic achievements, leading her to prioritise her studies with a fervour that earned her the label of a "nerd" by her peers.

Maura says that when it came time to decide in which academic area she would pursue her degree, it wasn't that difficult to choose, as she always liked the exact sciences. This inclination was reinforced in secondary school when she enlisted the help of a tutor for physics, who was concurrently studying in an engineering faculty. This event may indicate that her tutor, an engineering student, made the field even more appealing to her. It was a family discussion that cemented her decision, particularly a piece of advice from her father. "I spoke with my dad, and he suggested engineering, saying, 'It's a field with fewer women, which could be beneficial for you in the job market,'" she recounted. This blend of personal passion for the sciences and strategic guidance from her father guided Maura towards her pursuit of engineering.

Maura's academic transition into the engineering programme was initially harsh. "In the last quarter of twelfth grade, I started at a prep centre for the college entrance exams, which really helped me," she recalls. Her acceptance into the course brought about an immediate sense of culture shock. "My first lecture was in an amphitheatre during a physics class, a subject I usually liked, and yet I understood nothing. It was intimidating, I came home feeling like, I guess engineering wasn't for me, and seeing the sheer number of unfamiliar faces didn't help either," she explains about her daunting first experience. However, the unexpected onset of the COVID-19 pandemic became an unlikely catalyst for her integration into the university environment. "Covid, in a way, turned out to be positive for me. The isolation period gave me the space I

needed to adapt to university life," she reflects. During this time, Maura took the initiative to familiarise herself with educational technologies, exploring resources beyond the classroom. "All possible ways to investigate and study, and I learned this during the Covid period, with online classes. And when we returned, we just continued with the rhythm." This period of self-directed learning was fundamental, and upon returning to campus, she felt fully adjusted and ready to continue with the momentum she had built.

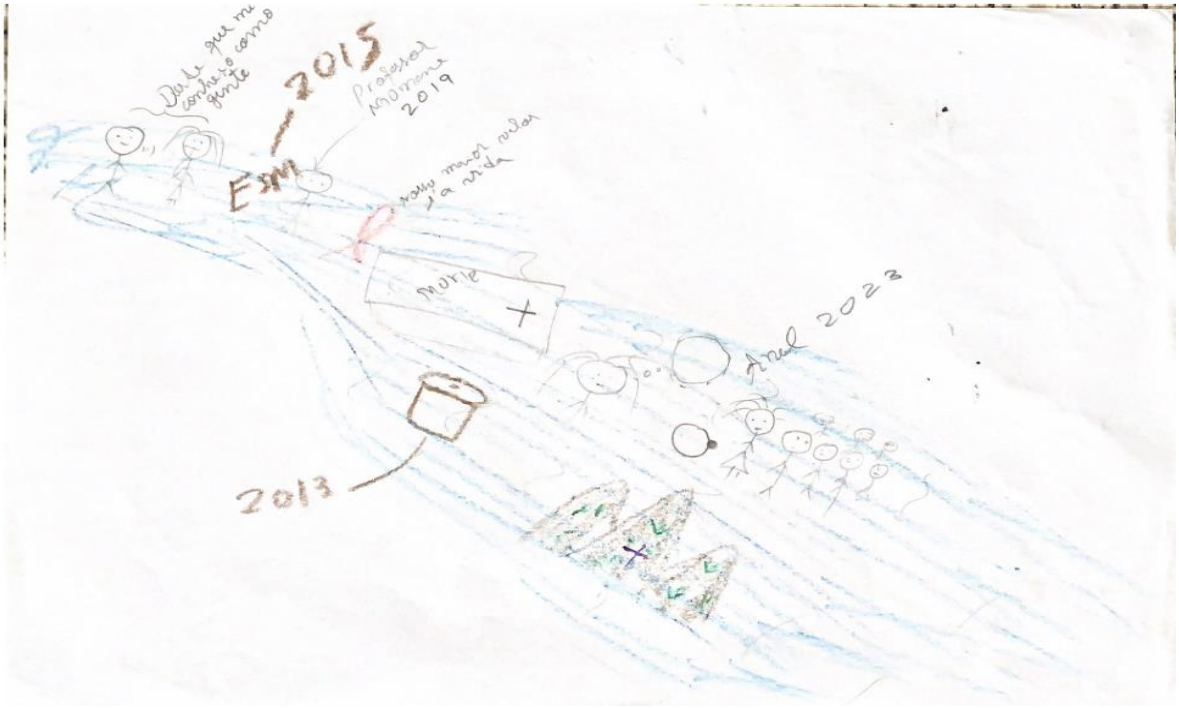


Figure 5*: Maura's River of Life*

**Larissa**

Larissa's life began with the promise and potential that education holds. Her academic journey was rooted in tradition, attending schools known for being traditional and well-respected in her community. In these formative years, Larissa faced health challenges that restricted her physical activity and educational experience. "I had breathing difficulties and unexplained fainting spells," she recounts, detailing the impact on her well-being and studies. Despite this adversity, her spirit remained firm, as she continued her education with determination. Larissa's perseverance is a stamp of her character. Her health concerns, which prevented her from participating in physical education and left her without a grade in that subject on her certificate, symbolise the challenges she has navigated throughout her life. Yet, she remains dedicated, undeterred by the unknown, whether it's the complexity of her health or the rigours of academia.

From an early age, her home was a library of inspiration, with racks lined with engineering books belonging to her older brother, a student of engineering himself. These texts ignited a spark within her, drawing her into a world of inquiry and fascination with the field of engineering. As she explored this domain, her passion for the subject deepened, and her curiosity persisted. When the moment came to choose her own academic path, her brother offered wisdom but no directive, leaving the choice to her with the words, "The decision is yours to make," he said. This autonomy was met with initial surprise from some members of her family—her mother had anticipated a future for her in medicine. Nonetheless, her family's initial surprise soon gave way to persistent support, providing a strong foundation for her to pursue her passion in the field of engineering with their full encouragement behind her.

Larissa's educational pursuit in engineering is a story interlaced with quiet personal battles that extend beyond academic rigour. Describing herself as someone who struggled with anxiety, Larissa found this characteristic to be a notable obstacle. Her anxiety often raised its head in the physical space of the classroom, and became an impediment, especially within the interactive environment of a classroom, holding her back from engaging fully in discussions and class activities. "I was more nervous and couldn't answer the questions," she confesses. Her schooling, confined to an all-girls environment, meant that her interactions with the opposite sex were limited, leading to a difficult transition when she entered the co-educational world of university. "When I arrived at college campus it was very challenging for me at first, because most of my classmates were male, and I was very afraid of talking with the boys...," she admits. However, with time and persistence, the initial discomfort faded, allowing her to adapt and become comfortable within her new academic community.

The COVID-19 pandemic brought a mixed bag of experiences for Larissa with its shift to online learning. Although she sometimes noticed a lack of engagement from her peers, she also discovered the convenience of studying from home. "Being at home made things more manageable," she explains, appreciating the ability to balance household duties with academic responsibilities. As she approaches the completion of her graduate studies, Larissa exemplifies

the integration of traditional values and modern technology in education. Her narrative is one of resilience in the face of health challenges, adaptability to new modes of learning, and dedicated pursuit of her academic goals. She is a living example of how educational technology can reshape learning pathways, offering solutions to overcome physical limitations.

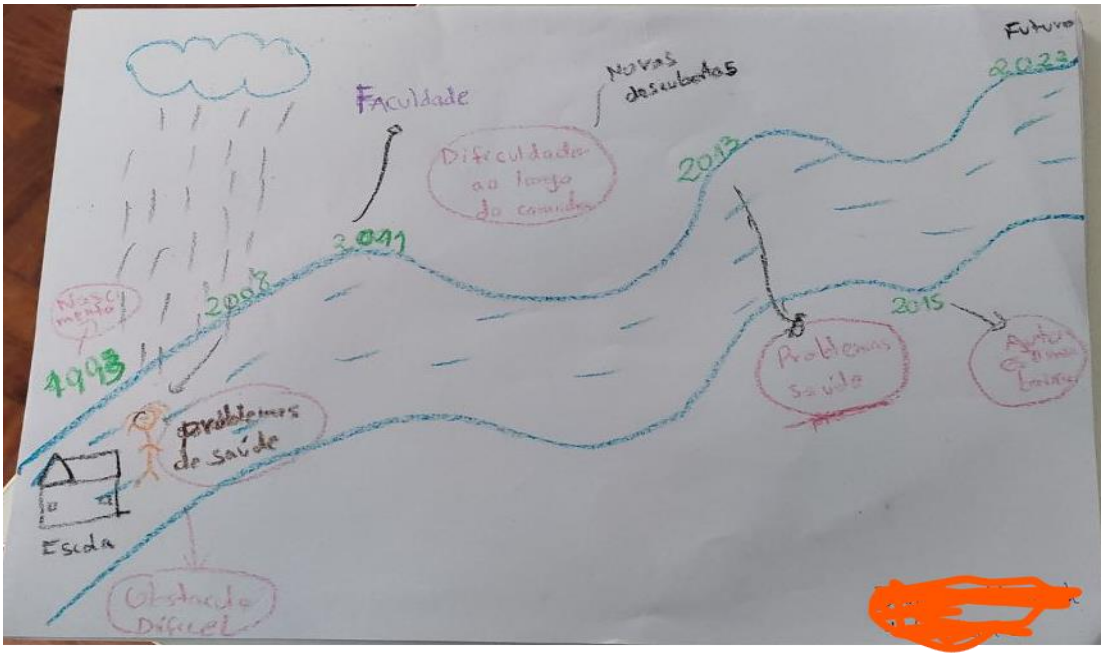


Figure 5*: Larissa's River of Life*

# Appendix G - Emergent Themes from Women Engineering Students' Experiences with Technology at UEM

| Theme | Sub-Theme | Sub-Sub-Theme |
|---|---|---|
| **Access to Technology** | Personal Computer Access | - Need for personal laptops<br>- Shared family resources |
| | Shared Resources Limitation | - Impact of shared technology on study flexibility |
| | Institutional Support | - Computer labs availability<br>- Scheduling conflicts |
| **Use of Technology in Learning** | LMS as a Learning Facilitator | |
| | Technology as an Enabler of Participation | - Comfort in virtual environments<br>- Overcoming shyness |
| | Inequity in Technological Proficiency | - Gender gaps in tech skills<br>- Male dominance in tech use |
| | Vula for Assignments and Quizzes | |
| **Perceived Benefits of Technology** | Flexibility and Balance | - Managing household and study responsibilities |
| | Increased Confidence and Empowerment | - Improved self-perception<br>- Empowerment through tech use |
| **Challenges and Barriers in Technology Use** | Technological Access and Distractions | - Distracting nature of technology<br>- Focus issues |
| | Financial Barriers to Technology Access | - Economic constraints affecting tech acquisition |
| **Cultural Challenges** | Cultural Stereotypes and Biases | - Effects of societal perceptions on participation |
| | Adaptation to Male-Dominated Environments | - Behavioral adaptations<br>- Appearance adaptations |
| **Support Systems and Empowerment** | Mentorship and Role Models | - Influence of female mentors<br>- Need for role models |
| | Scholarships and Financial Support | - Importance of financial aid for female students |