Experiences of women in STEM: Personal narratives illustrating the fluidity and nuances of the STEM pipeline

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Rapid advances in technology have resulted in a worldwide drive to enhance science, technology, engineering and mathematics (STEM) workforces to remain internationally competitive and ensure economic prosperity. Despite this, there is ongoing debate about the best strategies for promoting STEM literacy and building national STEM competencies. Women continue to be under-represented within the Australian STEM workforce, impacting Australia's national performance and STEM pipeline figures. Several factors have been determined as crucial components impacting females' perceptions of the STEM fields, and their drive to pursue employment in these areas. One method for analysing these factors is to explore the personal narratives of women in STEM and STEM-related fields to determine which factors impact their engagement with STEM. Our research contributes to this ongoing debate by providing insight into the personal narratives of eight women who participated within the *STEMinist Community of Practice* (CoP) research project, and their fluid experiences of the STEM pipeline. This paper explores the key factors and experiences of the participants, including how their careers progressed over time; and related potential solutions for increasing the number of women in STEM. Additionally, this paper explores the criteria for being considered a 'STEM professional', and how this impacts the fluidity of the STEM pipeline for women. We utilised a qualitative narrative research design through the worldview of interpretivism and employed a storytelling methodology. Thematic analysis was undertaken, and four key themes emerged: influence, perception, self-perception, and community of practice. The research questions are answered through a series of vignettes providing a rich conception of participant experiences. Key recommendations from this article are the development of further communities of practice to empower women within STEM fields, and adjusting the criteria of STEM professionals to include STEM educators, to address STEM pipeline issues.

Introduction

In 2023, there is still an emphasis on increasing the flow of graduates into STEM fields: the so called 'leaky STEM pipeline'. In the latest research in Australia and the US, reports are still exploring where the millions of invested dollars have been spent and seek to determine the impact of the thousands of STEM projects and programs spanning more than two decades (Australian Academy of Science, 2022). With regards to women in STEM, it appears that the pipeline is 'exceptionally leaky', especially in Australia where it is reported that only 16% of the STEM-skilled workforce are women and that 90% of all qualified STEM women are employed in non-STEM related fields (Australian Academy of Science, 2022).

We dislike the terms 'pipeline' or 'leaky pipeline' to describe people's STEM careers, but we are well aware that it has been used descriptively in research papers. Our article explores two aspects of 'leakiness', with one relating to the narrowness of the STEM pipeline as determined by the Australian Government and authorities, and the other aspect relating to the straightness of the pipe with regards to the actual complexity of the landscape for women and their career pathways. In continuing our account we abandon use of terms relating to pipelines, leaky or otherwise. We are focused on the complexity of the narratives relating to the lived experiences of a group of women in STEM (STEMinists, https://steminists.weebly.com/), and in many cases their struggle within the Australian landscape to be considered part of the STEM (education) community.

STEMinist research project

The STEMinist research project (2015 – ongoing but less active) community of practice (CoP) was formed to unite passionate individuals who dedicated their time to promoting STEM education in schools. Communities of practice (CoPs) are a collective of people sharing a passion or concern, who engage in informal learning to improve their practice, requiring three key elements: collective interest of the community, community engagement, increased visibility and practice (Wenger-Trayner & Wenger-Trayner, 2015).

The original STEMinist research team consisted of four experienced female academics, and several pre-service teachers and in-training female engineers who delivered Makerspace (Nadelson, 2021) projects to schools and communities (including rural and regional); professional learning to teachers and organisations; and presentations at local and inter-state conferences and events. This paper explores the experiences of the initial STEMinist women through interviews about their STEM career pathways. They were interviewed in 2016 and then re-interviewed in 2023, and their stories are presented below.

STEM and STEM education

Employment in the STEM fields has continued to grow in importance over recent decades in response to economic changes and priorities (Black et al., 2021), and it is the challenge of education to equip young people with the transferable skills required to navigate complex and challenging careers to meet this need (The Foundation for Young Australians, 2017). While referred to as a number of names, it is internationally agreed that these capabilities are of critical importance for preparing students for unknown working conditions essential to a country's economic success (Margot & Kettler, 2019; Timms et al., 2018).

Struyf et al. (2019) contended that a key component of developing 'STEM competent' students is through the compulsory education system. The driving force behind STEM development has led to all highly developed nations investing in projects and programs to improve this educational approach, and in-turn bolster STEM engagement and workforce numbers. In response, education systems have undertaken a focus on STEM to ensure that students are prepared for their futures with critical skills and knowledge (Akcan et al., 2023; Government of Western Australia, 2019). While debate over the exact definition of STEM education has been a continuous issue for invested parties (Barkatsas et al., 2018; Li et al., 2020; Timms et al., 2018), there is a general agreement that action needs to be taken to improve the quality of STEM education, to reflect industry expectations and authentic contexts (Margot & Kettler, 2019; Taconis & Bekker, 2023; Timms et al., 2018). The link between student achievement and engagement with learning is clear (West Australian Primary Principals' Association, 2018), and with student disengagement occurring from STEM at an early age (Fraser et al., 2021), it is critical that educators are supported to implement this pedagogical approach effectively.

Australian STEM workforce

Australia's Office of the Chief Scientist (2020) defined the STEM qualified workforce as those who reported post-secondary qualifications in the following fields of the Australian Standard Classification of Education (ASCED):

- Natural and physical sciences
- Information technology
- Engineering and related technologies
- Agriculture, environmental and related studies (Office of the Chief Scientist, 2020).

with mathematical sciences considered a sub-field of natural and physical sciences. The non-STEM qualified workforce refers to others who have achieved post-secondary qualifications in the other ASCED fields of education (Office of the Chief Scientist, 2020).

In 2016, there were more than 11 million people in the Australian labour force, with two million having a qualification in a STEM field (Office of the Chief Scientist, 2020). The data have shown that over the last decade there have been some very small improvements in the experiences of women in STEM. In 2006, 27% of STEM university graduates in the labour force were women, increasing to 29% in 2016 (Office of the Chief Scientist, 2020). According to the Office of the Chief Scientist (2020), women also represented 49% of the university qualified labour force with science (excluding mathematics) qualifications. More recently, between 2015 and 2021, women enrolled in university STEM courses rose from 70,378 to 92,162, indicating a 31% increase overall (Australian Government, 2023). While improvements are evident, there are still clear challenges to address, and research that investigates reasons for these gaps will continue to support the growth and improvement of the Australian STEM workforce.

Girls in STEM

Data has been collected over several years that considers girls' interests, engagement, and participation in STEM secondary subjects. One finding has been that girls display an early interest in STEM subjects that decreases over time. Through their 2023 *STEM Equity Monitor* Report, the Australian Government (2023) outlined that when asked, 31% of girls expressed an interest in engineering, and 62% were interested in science. They also reported decreased confidence between the ages of 12-13 and 18-25 for science (65-63%), technology (68-56%), engineering (51-27%) and mathematics (57-56%) (Australian Government, 2023). In addition, the 2023 *STEM Equity Monitor* reported survey data for

Year 6-8 students highlighting that 21% of girls indicated aspirations for a STEM career compared to 42% for boys (Australian Government, 2023). In Australia, despite years of focus, there have been few overall gains in STEM engagement, interest and participation for girls and women.

Exploring the decrease in confidence and engagement of girls in STEM over their formal schooling careers highlights that these are significant factors impacting their aspirations as STEM professionals. Other factors include pre-existing stereotyping, such as structural, cultural and organisational forces (Sáinz et al., 2019; Thébaud & Charles, 2018); a lack of female role models due to low participation rates from women (Devis et al., 2023; González-Pérez et al., 2020); exclusion from networks (Devis et al., 2023); and implicit bias impacting female self-confidence, academic efficacy and a sense of belonging (Clark et al., 2021; Devis et al., 2023). Exploring these factors is essential for the progression of women in the STEM workforce. This paper seeks to contribute to this discussion by exploring the complex and nuanced facets of life experiences from several women who were part of the STEMinist research project and determine key factors that influenced their engagement as STEM professionals.

Research questions

The overarching aim of the research was to interrogate the following question: *How do the STEMinist participants describe their STEM stories?*

To answer this, three subsidiary questions were developed:

1. What factors influenced participant engagement with STEM as a career choice?
2. What are the key experiences in the STEM stories of the STEMinist participants?
3. How have the careers of the STEMinist participants progressed over time?

Methods

Design

This study used a narrative research approach where participants willingly divulge their personal stories about reportable concepts or topics (Creswell & Guetterman, 2019). Through this process, this paper highlights an accessible form of data that is relatable and relevant to individuals (Creswell & Guetterman, 2019). The narrative approach is frequently defined with an interpretivist worldview and employs a storytelling methodology. This research project utilised a biographical narrative interview approach through personal experience stories to explore the impacts of the STEMinist Research Project on the career trajectories and perspectives of female seasoned academics, pre-service teachers, and in-training engineers.

Narrative design key characteristics

A number of key common characteristics are present across the narrative research approaches: literature is a minor consideration, and the fundamental emphasis is on learning from the participants within the setting (Creswell & Guetterman, 2019). The stories explored through these approaches are typically gathered through interviews and conversations and are then analysed by the researchers based on narrative elements. Through this process themes or categories emerge which assist in the narration of the story.

Sample

The sample for this project included experienced academics, in-training engineers, and pre-service teachers from a university in Perth, Western Australia (Table 1).

Table 1: Description of the sample of STEMinist women participating in the study

Pseudonym	Age	Country of origin	STEMinist role	Position in 2016
Sarah*	40-50	England	STEM education	Senior lecturer
Cherry*	50-60	India	STEM education	Senior lecturer
Beth	50-60	Australia	STEM education	Senior lecturer
Nora*	40-50	Romania	Engineer educator	Associate professor
Danielle	20-30	Australia	Education	Pre-service teacher
Faye*	20-30	Australia	Engineering	In-training engineer
Pearl	20-30	Australia	Engineering	In-training engineer
Sam	20-30	Australia	Engineering	In-training engineer
Ellen	20-30	Australia	Education	Pre-service teacher

* Vignettes were created from these interviews.

The 2016 research participants included experienced academics (n=4), in-training engineers (n=3), and pre-service teachers (n=2) (see Table 4). The participants responded to the following questions.

1. Why did you choose a STEM focus?
2. How have your STEM experiences changed over time?
3. How have your Makerspace experiences impacted your STEM focus?

The 2023 research sample was taken from a smaller number of members from the 2016 research group who consented to participate within this phase of the project. They comprised of experienced academics in STEM education (n=4), a pre-service teacher (now in-service) (n=1) and an in-training engineer (now in-service) (n=1). The participants responded to the following questions:

1. How has your life/career progressed since you were interviewed in 2016?
2. How did your STEMinist experiences impact your career and STEM focus?
3. Has your understanding of STEM changed since 2016?

Qualitative methods

The process of thematic analysis was utilised to determine specific patterns and consistencies within the responses from the participants. This approach included extensive discussions to determine major themes, and member checking to identify sub-themes within the dataset, which is a common approach within narrative designs (Braun & Clarke, 2006). According to Braun and Clarke (2006), thematic analysis produces rigorous findings which are valid and insightful, and is advantageous when highlighting similarities and differences between participants. Table 2 outlines the process of thematic analysis applied to the data. An inductive approach was utilised, which was implemented with few preconceptions.

Table 2: Overview of thematic analysis process
(adapted from Braun & Clarke, 2006; Nowell et al., 2017)

Phase	Action
Preliminary data examination	- Transcription immersion with research team members. - Multiple readings and discussions.
Coding	- Initial codes determined through multiple systematic readings. - Simplification of data through highlighting important concepts and patterns.
Themes	- Themes developed inductively, through the identification of patterns and consistencies between participants. - Themes reviewed and refined several times to determine meaningful and rational patterns for coherence. - Essential characteristics of each theme determined by the research team, and the narrative of each theme in relation to the research questions. - Peer reflection and member checking. - Consensus on theme definitions.
Drawing conclusions	- Development of logical findings and validity through making links between literature and qualitative analysis.

Findings

The findings are presented in two separate ways. Firstly, a selection of summarised vignettes of some STEMinist participant stories are shared to highlight the narrative behind the data. These vignettes have been formed using direct quotes taken from the 2016 and 2023 interviews, to tell the personal stories of the participants, which reflect crucial elements that are then explored through the more systematic presentation of the themes. The second section includes each theme and sub-theme developed through the thematic analysis, and examples of the type of item attributed to each theme.

Vignettes 2016-2023

Faye's vignette	Up to about Year Four, I had a real passion for maths and science. After Year Four, my way of thinking about maths and science was heavily influenced by my learning environment. Year Five is when I started gaining an understanding of the hierarchy within the schoolyard community (my peers) and this heavily influenced my interest in mathematics. It was in my opinion, as a child, that I either needed to identify myself as a nerd (someone who was good at math and science) or instead I would just be like one of the normal girls, who got normal – or average should I say – marks and had friends. Moreover, I then told myself I was too smart to have friends, so I stopped working as fast; I did not try as hard because I wanted to be normal and get average marks like the girls who seemed normal. I started to lose interest in my science classes, and I believe this way of thinking was heavily influenced by how I felt about my teacher. I did not particularly like my science teacher. Consequently, these bad vibes from my teacher connect to how I felt about science. Falling into the trap of thinking that being smart was dumb and not getting along well with my teachers were factors in my learning environment that were damaging to my interest in STEM subjects. During high school I underwent a significant transformation as a pupil. If you had asked my high school principal what he thought of me during lower school, he would say I was a ditz. I wasn't recognised as a pupil who would strive for academic success. I distinctly remember an assembly, when I was Year 11, and my maths teacher told my friend to pay close attention to the 95 Club Ceremony with the hope my friend would be a part of this club in 2 years' time – I was not on this same radar. At this time, no one would have thought that my predicted ATAR at the end of Year 12 would be 99 (out of 99.95) and that I would be standing on the stage of the 95 Club Ceremony sharing my past efforts and how they will help me succeed in university. This transformation occurred because I was able to shift my attitude towards my education and interest in STEM to something that was exciting and opportunistic. From being a part of MIS Makerspace I have learnt that what you learn and experience throughout a child's schooling is crucial to someone's decision about their tertiary area of study, and the importance of learning how to learn, and reflecting. The STEMinist experience had minimal impact on my career as no links to the group were formative in my career decisions and progression. But the group was an encouragement by meeting other women pursing an engineering career and provided confidence that there would be support in the future from other women in STEM.
Sarah's vignette	My dad who was the primary influence as he was very keen on natural science and the way the world worked and I spent many holidays in rock pools probing under rocks for interesting creatures and collecting them in a bucket with a

sense of awe and wonder. However, I was not originally going to be a science nerd when we lived in the UK. I was much more interested to study ancient history, and geography, and that was where I was headed. When I left the UK, I arrived in Australia in the beginning of Year 10; however, I was placed in a totally different context. I found I wasn't interested in the perspective of Australian history and geography and found that I was good at science. In Year 11, I was encouraged by my biology teacher to enter the science talent quest and spent many lunch times doing science experiments instead of trying to integrate into a world full of 'strange' Australian girls where I didn't feel at home. This turned my focus to the sciences, and I had some dedicated and focused teachers who saw potential in me.

I guess success is a powerful incentive, and when I won the biology prize in Year 12, I felt empowered to move forward and was easily granted entry to UWA (University of Western Australia) to study science. I knew I wasn't going to get into medicine, as I wasn't that good, so I gave up my dream of becoming a medical doctor. I completed my science degree and was offered honours, and although I loved microbiology and biochemistry, I wasn't keen to spend my days and nights talking to a test tube. There were also no jobs in the area for the small group of graduates, so a graduate diploma in education was the way forward. I wasn't sure I wanted to be a teacher – I don't think I joined the profession to make the world a better place. It was certainly more pragmatic, and I needed a job and wasn't sure what else to do. I remember very clearly being much more worried about knowing all the answers to difficult problems, rather than worrying initially about whether the students were able to understand.

I did my final practical at a school where there was a strong male presence. Actually, my head of department was physically intimidating to students and young staff (me at least). I stayed on there after my six weeks and kept working with a class of Year 8s until the end of the year. The faculty were very excited at the end of the year – they were hoping to get a man with experience in the following year. They did get a new staff member, but it wasn't a man with experience, it was me. I don't think the head of department was impressed at all. I must admit, I always felt a little outside the box when I was a young teacher: female and young, and therefore not in the usual science teacher demographics.

I found myself interested in further study when my sons were young - anything to improve the boringness of nappies, crying and being exhausted. So, I decided to complete my PhD in science education, and whilst the boys were asleep or at day care I worked on my research and data collection. I didn't work in academia until the boys were old enough to travel to school on the bus on their own. This transition was significant and led to the eventual development of the STEMinists.

The STEMinists have been, and continue to be, an interesting fun adventure. We have had the chance to share our narrative across the world, and it even brought me the opportunity to visit Antarctica as one of 100 influential women in STEM. I think the leadership opportunities were about doors that you would walk past, and think are closed, and then think – 'well, hang on a second'. I think we have had some spectacular impacts – having a PhD student from one of the original STEMinists is pretty amazing. It is exciting, because it's sort of generational, and that is leadership too – I think leadership is legacy building.

Cherry's vignette

The society I was born and brought up in valued educating their children, and moreover science and mathematics were perceived as subjects in which bright kids would succeed. At the same time, most female students would choose the humanities subjects (called ARTS) as their first choice. We also had two choices in high school maths: (i) Domestic Maths (popular with girls) and (ii) Algebra and Geometry (perceived as difficult).

My father was an agronomist – a senior officer and a scientist in the local government. He would do all sorts of experiments with the soil engaging me. Even while doing household chores like washing or cooking he would explain the chemical processes. This led to a relational understanding of science when taught in school and a perceivably difficult subject became my passion. The STEM acronym didn't exist then but in essence, we were doing STEM then and this practice continues.

Entering university, I could choose to enrol in humanities courses, while as my peers who had not studied science in school, could not enrol in science streams. Students enrolled in science were seen as bright kids and valued by society. While I am sure there would have been a sense of elitism, I had always just wanted to make a difference in society. At that time, my focus was on women, which over time has changed to female students.

Although I always enjoyed doing and learning science, I also believed science was difficult. Our Makerspace project made me realise STEM/Science can be enjoyable too. Each activity can be designed to the level of working of a given student/group by adjusting the level of difficulty in the given activity. Multiple concepts can be learnt in one activity. These experiences allow students to think critically, work in groups, and empathise with peers. I wish my teachers would have offered me a similar opportunity when I was in school.

I don't know where I will go, but I would like to see us [STEMinists] making change and heading towards excellence in this area. What I would like to see is impact, not at a university level, but in the educational fields. I see the future of Australia in our schools. Having workshops with more and more teachers, which will empower them and increase their self-efficacy, and motivate them to make a change in schools.

Nora's vignette	While in Romania – it was really nothing special in being a woman in engineering. Many of them choose to do this degree and nobody was talking about any 'gender' issues. Nobody told me (or any other girl) that there was a degree that a woman cannot do. My mum was an engineer, her sister a teacher, my uncle a doctor, my dad an engineer and a teacher, so… anyone could do what they wanted as long as they studied hard. At that time, going to university was not the norm. Very different today. The university lecturers had a 'duty' in making our life very hard so only the ones that could survive later should graduate. They were not friendly, and they did not worry how we felt. Our parents were also quite strict and tough. No rewards for things that you had to do well, no time to 'find yourself' overseas (we could not go anywhere overseas during the communist time anyway), and before coming to Australia I had not heard the words 'depression' or PMS. If you felt a bit under the weather and not very energetic – have some food or go for a run! During my PhD studies, I needed to spend months in the middle of Queensland at a fertiliser plant. Even after that experience, I did not realise that there was a 'gender' issue in engineering. I noticed there were not many women but did not notice any discrimination at work. It was not until working as a lecturer, that I realised women MIGHT be regarded differently in engineering environments. One of my fellow colleagues, a woman, told me that during a meeting, one of my other colleagues disagreed with my proposal of introducing a specific computer simulation in a unit… because 'I am a woman'. Somehow, from there on, I started to listen to other stories – to find out that it is challenging to be a woman in engineering. The Makerspace project [STEMinists] was one of the best projects I took part in since working at the university. The idea of bringing together academics (both teacher and engineer educators), student engineers and student teachers, is for me the ideal recipe for inspiring young minds. I will never forget their feedback [the bitterness of my fellow engineering women academics] after I invited them to attend the opening of the Makerspace in the pavilion. They did not like the fact that 'all was pink' and that they were called 'girls' ("we and the students are not girls or ladies, we are women!"). That was the feedback that was important for them, and they were not shy to tell me that while the project 'might be okay, you managed to wrap it in pink and also add a pink ribbon to it'. Meanwhile, the engineering students, they told me that 'pink is awesome'. I found this interesting, the difference. I realised that all their childhood and school years they were told that 'pink is for girls' and 'girls don't do engineering'. Would this be the reason many of the women will tell you they do not want to be associated with 'pink'?

Results

Thematic analysis and themes

This sub-section includes the overview of the themes and sub-themes as developed through the thematic analysis. Definitions are included, as well as the qualitative results, and examples of items relating to each theme.

The 2016 STEMinist participant data formed a comprehensive picture of the factors which influenced engagement with STEM, impacts of the STEMinist CoP, and related perceived benefits (Table 3). The 2023 STEMinist participant data provided a nuanced ending to the stories of the STEMinist team and explored the long-term impacts of the STEMinist CoP.

Table 3: Thematic analysis results from the data

Theme	Sub-theme	2016 data				2023 data			Sub themes total	
		Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Yr. 2016	Yr. 2023
Influence	Family	5	5						10	
	School	21	36	3					60	
	Environment	6	1						7	
	Gender	3	7	1					11	
Sub-total		35	49	4					88	
Perception	Content and Skills	1	1				3		2	3
	Translational	5			1	3	1		5	4
	STEM perceptions	6	5	1	5		11	7	12	18
Sub-total		12	6	2	6	3	15	7	19	25
Self-perception	Predisposition	7							7	
	Ability	10	9	1		4	2	1	20	7
	Engagement	6	10		1	9	1		16	10
Sub-total		23	19	1	1	13	3	1	43	17
Community of practice	Community	2	2	12		4	2		16	6
	Mentor/mentee		5	8	1	4	1		13	5
	Connections		1	8		15	4	1	9	20
	Women in STEM	2	3	9			1		14	1
Sub-total		4	11	37	1	23	8	1	52	32
TOTAL		74	85	43	16	39	26	9	202	74

Theme 1: Influence

The first theme drawn from the responses was *Influence*, with sub-categories Family (10), School (60), Environment (7) and Gender (11). This theme was indicated a total of 88 times by the respondents, making it the highest indicated theme across the dataset. Influence included any items (positive or negative) which directly referred to experiences that changed or impacted participant perceptions or engagement with STEM. The following items highlight examples from each sub-theme (Table 4).

Table 4: Sub-categories for Theme 1. Influence

Influence includes any items referring to experiences that the participant described which has changed their perceptions or engagement with STEM.	
1. Family	Mother, father, siblings or other. *My parents wanted me to do engineering, and since I could not do what I had initially wanted, I thought why not.*
2. School	Teachers, peers, awards, opportunities. *In Year 11 I was encouraged by my biology teacher to enter the science talent quest and spent many lunch times doing science experiments instead of trying to integrate into a world full of 'strange' Australian girls.*
3. Environ-mental	Economic, political. *No job at the end [studying drama and Shakespeare] so I needed to reconsider my options. Again – economic and political situation'.*
4. Gender	Culture, expectations, prejudices. *While in Romania – it was really nothing special in being a woman in engineering. Many of them chose to do this degree and nobody was talking about any 'gender' issue'.*

Theme 2: Perception

The second theme drawn from the responses was *Perception*, with sub-categories Content and Skills (2), Translational (5) and STEM Perceptions (12). The theme was indicated a total of 19 times, making it the lowest indicated theme across the dataset. It included any items (positive or negative) that indicated participant perceptions about STEM or STEM Education. The following items highlight examples from each sub-theme (Table 5).

Table 5: Sub-categories for Theme 2. Perception

Perception relates to perceptions of the participants about STEM and STEM education.	
1. Content/ skills	Access, mastery. *The skills and knowledge you gain in studying STEM subjects are transferrable across a plethora of disciplines.*
2. Transl-ational	Applicational relevance to life, future career, general development of society. *Then there is also the relevance to everyday life, technology in particular is a fine example when one looks at its uses that have progressed human development; communications, transportation, health and safety.*
3. STEM percep-tions	Positive or negative perceptions of STEM or STEM Education within society. *The more that I myself am educated about the current advances in STEM worldwide and the advances that occurred long before our time, the more I have grown to view STEM as being vital in young education.*

Theme 3: Self-perception

The third theme drawn from the responses was *Self-perception*, with sub-categories Predisposition (7), Ability (20) and Engagement (16). The theme was indicated a total of 43 times, ranking it third out of the four themes. Self-Perception included any items (positive or negative) where participants referred to their personal relationship with STEM (Table 6).

Table 6: Sub-categories for theme 3. Self-perception

Self-perception relates to participant perceptions of their own relationship with STEM or STEM education.	
1. Predis-position	Perceptions of their natural aptitude to engage with the STEM disciplines. *I have always been a very curious person, evening growing up I always enquired why things happened the way they did, which I support can be attributed to a love of learning.*
2. Ability	Perceptions of their capacity for being successful, or their perceptions of being success/unsuccessful. *To get the best ones, you needed to sit a very tough exam (language and math) to get into the best ones, in Year 8. As I was a good student, it made sense to apply and sit an exam to a STEM high school. I got in and I did well.*
3. Engage-ment	Enjoyment or displeasure with STEM or STEM education. *I love practicality, I love thinking outside the box, I love finding solutions to everyday problems, I love asking the right questions… I love STEM.*

Theme 4: Community of practice

The fourth theme drawn from the responses was *Community of practice*, with sub-categories Community (16), Mentor/Mentee (13), Connections (9) and Women in STEM (14). The theme was indicated a total of 52 times, making it the second highest indicated theme (Table 7). Community of practice included any items referring to participation within the STEM/STEMinist community. The importance of a Community of practice is not discussed within this paper and will feature in a future publication.

Table 7: Sub-categories for Theme 4. Community of practice

Community of practice includes any items referring to perceived value of being within the STEM/ STEMinist community.	
1. Commun-ity	Experiences and opportunities relating to the internal STEMinist CoP. *'The Makerspace [STEMinist] experiences have contributed to my sense of STEM community. It allows me to pass on information and knowledge while also allowing me to learn new things. It has been good to see individual interest emerge with different people finding sharing different STEM information that I would not have found myself, broadening my knowledge and gaining a 'contagious' enthusiasm for a broader range of topics.*

2. Mentor/ mentee	Experiences of being mentored, or opportunities for mentoring others. This excludes specific mentions of women in STEM who acted as mentors. *Being part of Outreach led me to volunteer for the Makerspace [STEMinist] as I thoroughly enjoyed my mentor experience. I am glad that I have had one of the best experiences with Makerspace [STEMinist] and I would love to continue doing this for as long as I can.*
3. Connect-ions	Connections to STEM professionals. *The idea of bringing together academics (both teacher and engineering educators), student engineers and student teachers is for me the ideal recipe for inspiring young minds.*
4. Women in STEM	Influential or inspirational experiences relating specifically to women in STEM mentors. *One of them was a female and I immediately identified with her. After listening to her talk, I thought to myself, 'I want to be like her.*

Discussion

Several factors were indicated to impact the participants' engagement with STEM as a career choice:

- Influential factors,
- Perceptions of STEM, and
- Participant self-perceptions of their relationship with STEM.

Influential factors

All participating STEMinists reported that formal schooling had been a significant influential factor in their career journey in STEM. Whilst most were positive, and reported an influential educator who engaged them or recognised their potential, a smaller number outlined negative experiences. These included disengaging educators, peer influences and self-image issues. Research over a decade has outlined how education in primary, secondary and tertiary sectors have impacted on the continued engagement of STEM: Australian Government (2023), Fraser et al. (2020), Timms et al. (2018) and Wiebe et al. (2018) to name a small number. This extensive body of knowledge highlights the importance of formal schooling in the development of STEM aspirations and raises an interesting question about the value of educators in the challenge to contribute to a more substantial Australian STEM workforce. As such pivotal cogs in the process of engagement through critical phases of growth and development, why are educators not included within Australia's STEM workforce definition? Additionally, this excludes STEM professionals who transition into STEM education, leading back to the notion of the 'leaky pipeline', even though they are still crucial to inspiring the next generation and continue to positively impact the STEM workforce. This exclusion may directly impact self-confidence, academic efficacy, and a sense of belonging, which are outlined as barriers by Clark et al. (2021) and Devis et al. (2023).

A secondary influence identified from the responses was family, and typically outlined positive experiences and expectations. Holmes et al. (2017) explain that a child with a parent or carer already working in STEM is positively influenced to develop aspirations towards a STEM career. While family has capacity to be highly influential on decisions to pursue STEM, gender expectations can act as barriers. A study completed by Lloyd et al. (2018) identified that parents were more likely to have STEM university aspirations for male children, than they do girls. Typically, the respondents only reported positive influences from their parents; however, this is likely due to the sample having been actively engaged by STEM and encouraged by their families, and therefore it would be interesting to further investigate perceptions of girls and women who were not encouraged in the same ways.

While gender relating to family was not identified as negative within this study, there were other facets of gender that were reported. Some participant comments related to concepts identified by Sáinz et al. (2019) and Thébaud and Charles (2018) as pre-existing stereotyping issues which may impact (positively or negatively) confidence and engagement of girls during formal schooling, and further highlights the complexities, nuances, and influences of women pursuing STEM careers.

Perceptions of STEM

Perceptions of STEM, including skills/content, translational applications, and perceptions of STEM importance were also factors identified through the data. Typically, participants spoke positively about the real-world applications and importance of STEM. A significant body of research has established the critical nature of STEM for addressing the 'grand challenges' of humanity (e.g. Freeman et al., 2019; Sheffield & Koul, 2021; Tytler et al., 2019); however, it is also essential that this understanding is commonly perceived within society to continue driving positive change and improving the STEM workforce. As reported by the Australian Government (2023) through the *YouthInsight 2022-2023* report, on average 79% of mothers and 83% of fathers identified general STEM skills as essential for future careers. In addition, in the *2021 Youth in STEM* report, approximately 90% of youth perceived STEM skills to be important (Australian Government, 2021). It is evident that general perceptions of STEM and related competencies are viewed as essential, which indicates that other factors may be more significant in causing disengagement from STEM professions.

Participant self-perceptions of their relationship with STEM

Perceptions of predisposition, ability and engagement with STEM were also indicated as influential in electing to pursue a career within the STEM professions. As female self-confidence, academic efficacy, and a sense of belonging are critical factors in engagement with STEM (Clark et al., 2021; Devis et al., 2023), it is not surprising that a number of respondents provided self-deprecating remarks about their own capacities and confidence, while others identified that they felt they had the right dispositions to study STEM. This likely impacted their career aspirations in a number of ways. In seminal research, Bandura and Walters (1959) and Emmons and Diener (1986) outlined that humans select activities which are based on their perceived competencies and preferences, therefore making self-perceptions critical to the development of the STEM workforce.

Career progression

The University of Queensland (2023) evidenced that the average person changes jobs every 2 years and 9 months, indicating that a person may have approximately 16 jobs over their lifetime. In terms of careers, the average person tends to have 3-7 careers prior to retirement, and this is trending towards 5-7 for the upcoming workforce generation. Related to this, an interesting phenomenon that arose from our data but wasn't categorisable into a theme, was the 'accidental' pursuit of STEM or STEM education careers described by several participants. Table 8 outlines the early intended career aspiration of each participant, their reason for diverting from that career into a STEM field (if applicable), their career or study foci in 2016, and their career trajectory in 2023.

An interesting point highlighted through the responses, was that most of the STEMinists hadn't followed their original career choices. Reasons for change varied significantly, and included work opportunities, academic performance, and study opportunities. The pre-service teachers and in-training engineer STEMinists had already experienced several career pathway changes in the 7 years since they had originally participated.

Table 8: Overview of participant intended career, career diversion, career/study 2016 and career/study 2023

Pseud-onym	Country of origin	Intention early life/ Pre-STEMinist	Reason for diverting	Career/ study 2016	Career/ study 2023
Sarah	England	Medical doctor	Grades	Senior lecturer	Associate Professor STEM Education
Cherry	India	Science professional	Changing lives of women	Senior lecturer	Associate Professor STEM Education
Beth	Australia	English, French and modern history	Lack of study opportunities	Senior lecturer	Transition to retirement from Associate Prof. STEM Education
Nora	Romania	Literature, philosophy and drama	Lack of work opportunities	Associate prof., chemical engineering	Professor, Chem. Engineering Education
Danielle	Australia	Zoologist	Lack of work opportunities	Pre-service teacher (primary)	PhD candidate/ Sess. academic (STEM Educ.)
Faye	Australia	STEM professional		Engineering student	Engineer
Pearl	Australia	Medical doctor	Grades	Engineering student	
Sam	Australia	Engineering		Engineering student	
Ellen	Australia	STEM education		Pre-service teacher (primary)	Other

Recommendations

Through the Australian Government initiative, *Women in STEM Ambassador*, Professor Lisa Harvey-Smith promoted STEM:

> My vision is to make STEM a place for everyone. To achieve that, my team and I work on initiatives that are evidence-informed and focused on impact... I'm glad you're here. Together, we can make an impact and achieve equity in STEM. (Women in STEM Ambassador, 2023).

While there is a positive promotion of STEM, this equity does not include anybody involved in STEM *education* at a primary, secondary, or tertiary level. This provides a narrow definition of STEM to only those who are working in research and industry within these professions and publishing within the narrow confines of the ASCED fields. One of the key recommendations of our article is to review the Australian STEM workforce definition to be more inclusive of educators, who play a pivotal role in the development of the STEM workforce, through reflection of the USA definition. Significant bodies of knowledge attribute engagement and career paths to influential schooling, highlighting the powerful impact that educators have on children, and their capacity for improving the STEM workforce.

The small sample size in this study is a limitation to applying these findings in other contexts. As shown through the vignettes and themes, career pathways relating to STEM are nuanced and complex. It would be impactful for researchers to continue interrogating factors that influence STEM career pathways, particularly for girls and women, within a range of contexts, including those who have felt disconnected or disengaged with STEM.

Conclusion

During the *8th International Day of Women and Girls in Science* in 2023, UN Secretary-General António Guterres underscored the urgent need to empower girls to lead in science and innovation, aiming for a sustainable future. He revealed a striking statistic: only one-third of global researchers are women, a gap he attributed to structural and societal barriers. Guterres highlighted the enduring gender disparity in STEM fields, exacerbated by the Covid-19 pandemic, and argued that this inequality not only squanders potential talent but also narrows the potential for scientific and technological progress. He advocated for incorporating women's perspectives in these areas to ensure wide-reaching benefits (United Nations, 2023).

Amid rising demands for innovation and skilled STEM professionals, the under-representation of women in these fields remains a concern despite national progress. Our research delves into the stories behind the statistics, exploring the complex career paths of women in STEM, or "STEMinists". It examines common themes across their experiences, including education, family influence, self-perception, and the value of STEM, stressing the importance of addressing factors that deter engagement with STEM disciplines. This approach sheds light on the nuanced journey of women in STEM, challenging the oversimplified concept of a "leaking pipeline" by acknowledging the diverse career trajectories and the pivotal role of STEM educators in fostering the next generation.

In Australia, notable strides are being made towards inclusivity in STEM through *The Australian Pathway to Diversity in STEM Review* (Australian Government, 2024). This comprehensive strategy, laid out in four key themes, calls for a coordinated government effort to enhance diversity and inclusion. It emphasises the creation of a safe, inclusive work environment, the importance of lifelong learning from an early age, and the need to shift societal perceptions to value diverse knowledge within STEM. By advocating for these systemic changes, the review aims to cultivate a more inclusive and dynamic STEM workforce, recognising the crucial role of educators in integrating STEM culture within educational settings and encouraging young women to confidently pursue their interests and capabilities in this field (Australian Government, 2024).

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