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Investigating STEM identities of rural female learners and developing strategies to enhance STEM subject choices: A case of two rural South African schools

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Abstract

In this study, we investigated the STEM identities of rural Grade 9 girls and examined how a career-awareness intervention shaped their STEM knowledge, confidence, and subject-choice intentions. Findings showed that learners initially held weak STEM identities because of limited and often inaccurate understanding of STEM careers and Grade 10 subject pathways, all of which hindered informed decision-making. The intervention, delivered through STEM professionals and a careers booklet, improved learners' understanding of STEM fields, strengthened their sense of belonging in STEM, and increased interest in pursuing STEM careers typically viewed as male-dominated. Learners also reported greater confidence in selecting mathematics and science for Grade 10, attributing this shift to the guidance and exposure received during the programme. This study contributes new evidence from rural South Africa demonstrating that even a single, context-relevant intervention can meaningfully enhance STEM identity and readiness for STEM subject choices in girls.

Keywords: career awareness, intervention, rural female learners, STEM identity, subject choice

Introduction and background

Girls' participation in STEM remains disproportionately low, particularly in rural contexts where sociocultural expectations, gender stereotypes, and limited exposure to science, technology, engineering, and mathematics (STEM) opportunities continue to shape schoolgirls' engagement and sense of belonging in STEM fields. The U.S, Census Bureau (2022) described rural areas as geographic spaces characterised by low population density, small settlement size, and/or significant distance from major urban centres. The U.S. Department of Education (2025) further highlighted that rural communities face unique educational challenges, including limited resources, teacher shortages, and economic constraints, while also functioning as central community hubs that support local cohesion and identity. In Africa, rural communities are often marked by persistent structural underdevelopment, limited infrastructure, and restricted access to essential services despite representing the majority population in many countries (Zadawa & Omran, 2020). Challenges that affect rural communities are accelerated when it comes to women and girls in those areas.

Msambwa et al., (2025) have demonstrated recently that environmental factors such as gender stereotyping, lack of supportive learning environments, and restricted access to role models significantly weaken girls' STEM identities and participation in STEM subjects. These scholars defined STEM identity as the notion of belonging in STEM disciplines, shaped by how individuals interpret scientific experiences and how sociocultural environments influence those interpretations. Schoolgirls often receive limited and sometimes inaccurate information about STEM careers and subject pathways, and this contributes to reduced confidence and restricted aspirations in pursuing STEM-related careers (Archer et al., 2020; Blotnicky et al., 2018).

Although existing research highlights the influence of stereotypes, inadequate career knowledge, and limited representation on girl's participation in STEM as learners, there is little empirical evidence from rural South African schools that examines how targeted interventions can strengthen rural schoolgirls' STEM identities and support informed subject-choice decisions. This gap is critical because Grade 9 learners must select specialisation subjects in Grade 10 that determine their future STEM pathways (Department of Basic Education, 2012). In this study, we address this gap by investigating the STEM identities of rural Grade 9 schoolgirls and examine how a STEM career-awareness intervention influences their understanding of STEM careers, their confidence, and their readiness to choose STEM-related subjects. The research questions for this study were:

- How do rural schoolgirls as learners understand STEM careers and perceive their STEM identities before a career-awareness intervention?
- How does the intervention influence schoolgirls' STEM identity development and their intended Grade 10 STEM subject choices?

Theoretical framework: Stem identity

This study is guided by the STEM identity framework developed by Carlone and Johnson (2007). They define STEM Identity as one's recognition of oneself and others as a STEM person. They conceptualised STEM identity through three interconnected components: competence; performance; and recognition. Competence refers to scientific knowledge and the capacity to understand the world scientifically, performance describes the ability to demonstrate this knowledge, and recognition involves both self-recognition and being recognised by others as a STEM person. These components are shaped by social factors such as gender, ethnicity, and cultural expectations, making the framework particularly relevant for understanding the experiences of rural girl learners, many of whom often have limited and sometimes inaccurate knowledge of STEM careers resulting in weak competence in understanding STEM pathways (Msambwa et al., 2025). Their difficulty in articulating STEM career choices and subject requirements relates to performance, interpreted by the framework as the ability to demonstrate STEM understanding to others. This makes the STEM identity framework appropriate for this study because it accounts for how gender, culture, and social context shape learners' identification with STEM fields, which is central to understanding the experiences of rural girls at school.

Literature review

STEM identity among female learners

STEM identity significantly influences students' academic achievement, persistence, and career aspirations (Singer et al., 2020). However, schoolgirls often encounter gendered beliefs that position science and technology as masculine domains, and this undermines their confidence and sense of belonging in STEM (Grimalt-Álvaro et al., 2025). Research shows that schoolgirls struggle to identify with scientists presented in curricula and textbooks that continue to portray STEM as a male-dominated space (Makarova et al., 2019). These identity challenges are amplified in rural contexts where cultural expectations often reinforce traditional gender roles and prioritise caring professions over technical ones for girls (McNeill & Wei, 2025). As a result, many rural schoolgirls internalise limiting beliefs about their capability to succeed in STEM, which, in turn, shapes their subject choices and long-term career aspirations.

Gender stereotypes and barriers to STEM participation

Gender stereotypes represent a well-documented barrier to girls' participation in STEM education globally. Persistent beliefs that STEM requires innate brilliance, an attribute stereotypically assigned to males, discourage girls from pursuing STEM pathways (Sáinz et al., 2020). However, Shin et al. (2016) have argued that stereotypes concerning girls' ability to participate in STEM can be broken down through the involvement of women who function as role models. They also believe that this will boost girls' sense of belonging to STEM and reinforce the idea that hard effort is the key to success in STEM.

According to Archer et al. (2020), girls often rely on emotional experiences or limited exposure rather than informed knowledge when making career-related decisions, thus reducing the likelihood of selecting STEM subjects in high school. In rural areas, these effects are compounded by environmental disadvantages, including limited access to STEM role models, fewer resources, and reduced opportunities for career exposure (Grogan, 2019). These factors contribute collectively to weaker STEM identities among rural schoolgirls.

Interventions supporting girls' participation in STEM

Interventions that expose girls to relatable STEM professionals and accurate career information have proven effective in strengthening their STEM identity (Singer et al., 2020). Providing girls with opportunities to interact with STEM role models, particularly those who share similar cultural or rural backgrounds can challenge stereotypes and demonstrate the attainability of STEM careers. Makola et al. (2021) asserted that career discussions are more impactful when facilitated by industry professionals discussing their experiences since this motivates learners to choose and follow analogous career trajectories. Career awareness programmes, such as workshops and career booklets, have also been shown to increase learners' understanding of STEM pathways and to encourage more informed subject selections (Kang et al., 2023). These programmes are especially critical for Grade 9 learners, who must select Grade 10 subjects that will determine their access to STEM careers (Department of Basic Education, 2012).

Research methodology

Research design

For this study, we adopted a qualitative case study design, appropriate for investigating how rural schoolgirls' STEM identities develop in their real-life schooling context. A qualitative case study design is an in-depth, intensive investigation of a specific, bounded phenomenon such as an individual, group, organisation, or event in its real-life context (Yin, 2012). It uses many different data sources to provide a comprehensive, nuanced understanding of complex issues, rather than just statistical analysis. For this study, we worked with two rural South African schools, and this allowed us to examine processes, meanings, and changes over time as experienced by the participants. This design was suitable because the study sought to understand how and why a STEM career-awareness intervention could influence learners' perceptions, identities, and subject-choice intentions. The choice of a case study is also supported by the study focus on a specific population (in this case rural Grade 9 girls), a specific phenomenon (STEM identity), and a specific intervention (career awareness programme), all investigated in their natural context as recommended in qualitative educational research.

Sampling strategy and participants

We used a purposive sampling strategy to select participants who met the inclusion criteria: schoolgirls enrolled in Grade 9 attending one of the two selected rural schools. Our participants were 40 learners, 20 per school, all of whom participated in the pre-intervention focus group interviews. The number of participants was determined by the number of available Grade 9

girls at the schools and their willingness to participate in the study, the need for manageable, interactive focus groups, and the qualitative aim of generating rich, in-depth insights rather than statistical generalisations. Although this represents 15% of the total female Grade 9 population across the two schools (267), the sample was sufficient for a qualitative case study and allowed for recurrent themes and patterns sufficient for data saturation. The Grade 9 learners were purposefully selected because at this level learners must choose Grade 10 specialisation subjects, which directly shape their eligibility for STEM pathways (Department of Basic Education, 2012). Since subject choice decisions must be made in Grade 9, girls' understanding of STEM identity formation before and after an intervention is relevant.

Intervention and data collection procedures

Data was collected in two stages: at pre-intervention interviews and at post-intervention focus group interviews that were conducted after the completion of the STEM career-awareness programme.

The intervention

The intervention consisted of a career awareness workshop facilitated by four STEM women professionals and three male STEM professionals, all originally from rural backgrounds. Their presence was intended to support recognition and identification processes by exposing learners to relatable STEM role models. The programme included presentations on STEM careers, informal discussions among learners and STEM professionals, and the distribution of a career booklet containing accurate information on STEM pathways and subject requirements. This design ensured a direct link between the intervention and the data collected, with the pre-interviews establishing learners' baseline knowledge and STEM identities, and with post-interviews capturing any changes attributable to the intervention.

Data Collection

Focus group interviews were conducted using semi-structured questions aligned with the study's research questions. Pre-intervention interviews were conducted two months before the workshop, taking into account examination and holiday schedules. Post-intervention interviews were conducted one month after the workshop to allow learners time to reflect and integrate new knowledge. All interviews were audio-recorded and later transcribed. Learners were encouraged to respond in their preferred language, with one of the researchers, who was fluent in a local language, providing translation assistance as needed.

Data Analysis

Data was analysed using Braun and Clarke's (2006) six-phase thematic analysis approach, which enabled a systematic examination of learners' knowledge, perceptions, and identity shifts before and after the intervention.

Phase 1: Familiarisation with the data

All audio-recorded focus group interviews were transcribed, read, and re-read by the research team to gain an overall understanding of the learners' baseline career knowledge, STEM identity perceptions, and subject-choice intentions. This process ensured immersion in both pre- and post-intervention data sets.

Phase 2: Generating initial codes

We coded meaningful units related to learners' understanding of STEM careers, misconceptions and knowledge gaps, identity statements (related to confidence, belonging, and self-belief), and intended Grade 10 subject choices. Coding captured both semantic and latent meanings in responses.

Phase 3: Searching for themes

Codes from pre-and post-intervention transcripts were organised into preliminary themes. Examples included limited career knowledge, identity uncertainty, influence of role models, improved confidence, and subject-choice clarity.

Phase 4: Reviewing themes

Themes were compared across pre- and post-intervention data to ensure that they represented accurately the coded extracts and broader data patterns. At this stage, themes were refined to show clear contrasts between pre-intervention misconceptions and post-intervention improvements.

Phase 5: Defining and naming themes

Themes were clearly defined in relation to the theoretical framework (competence, performance, recognition).

Table 1
Components of identity

Identity Component	Description
Competence	Accuracy of STEM career knowledge
Performance	Ability to articulate appropriate subject pathways
Recognition	Seeing oneself as capable of belonging in STEM fields

Themes were labelled to reflect both identity development and subject-choice shifts.

Phase 6: Producing the report

Final themes were woven into the findings to illustrate how the intervention influenced learners' STEM knowledge, identity, and subject-choice decisions. Descriptive numerical

shifts (e.g., changes in the number of STEM career choices) were used only as supportive indicators rather than statistical evidence.

Findings

The findings are presented according to the key themes that emerged from the analysis of pre- and post-intervention focus group interviews. The themes capture learners' baseline understandings of STEM careers and subject choices, the misconceptions and identity constraints present prior to the intervention, and the shifts in knowledge, confidence, and STEM identity after the career-awareness workshop.

Learners' initial career knowledge and STEM awareness

Before the intervention, most learners expressed limited and often inaccurate knowledge of STEM careers and subject pathways. Although 29 of the 40 participants named at least one preferred career, some did not seem to understand the difference between STEM and non-STEM careers. Of the 29 learners who responded to career choices, eight chose non-STEM careers. These are careers not requiring mathematics and science as core prerequisites, such as acting, law, journalism, and recreational therapy. Four responses combined a STEM and a non-STEM career; learners listed two unrelated careers, one requiring STEM subjects, such as medical doctor, and one that does not, such as social worker. Nevertheless, 17 learners chose either one or two STEM-related career choices, e.g., mechanical engineer and/or science teacher. Of the learners, 11 did not provide any career choice, which suggests that they were either unaware of the available options or had not yet given the matter any thought.

Learners' career choices, whether STEM or non-STEM, did not always appear to provide persuasive evidence that they comprehended what their chosen profession options included. Explanations for their career choices revealed significant misconceptions. For instance, several learners who chose mechanical engineering described the profession as "fixing cars" or "making finished cars," reflecting confusion between engineering and automotive repair. This could be a result of the prevalent usage of interchangeable terminology, or because learners had not been exposed to or taught about mechanical engineering, leading them to believe that this professional occupation is limited to fixing vehicles.

Similarly, learners who indicated that they wanted to become doctors did not distinguish between different medical specialisations or academic versus clinical doctorates. For example, when a learner who aspired to be a doctor was questioned if he wanted to be a medical doctor or academic doctor, his reaction was, "I want to be a doctor-doctor," suggesting a medical doctor. These misconceptions suggest a lack of STEM career exposure and limited opportunities in their schooling environments for career guidance.

Some learners attempted to rely on personal or community experiences when describing careers, such as associating dermatology with cosmetics or recreational therapy. A learner who stated that she wanted to be a recreational therapist characterised it as "someone who helps people deal with their emotions and relax." This answer is incorrect since a recreational

therapist is someone who plans, directs, and coordinates recreation-based medical treatment programs for people with impairments, injuries, or illnesses. This further demonstrates limited formal knowledge about career requirements and/or occupational functions.

Nevertheless, a small number of learners displayed more accurate understanding. For example, when a learner who aspired to become a paediatrician was asked to elaborate on the nature of the profession, she explained, "It is a doctor for children." Similarly, another learner who chose dermatology stated, "a dermatologist is a skin doctor who deals with skin conditions, [like] skin conditions that are caused by cosmetics." Their understanding of these careers appeared to stem from prior exposure through events such as career expos or interactions with family members working in STEM-related fields. For instance, one learner explained that her school had organised a career expo, and it was during this event that she was introduced to and learned about various STEM careers. This variation indicated disparities in learners' access to career information, thereby reinforcing the need for structured career-awareness interventions.

Emotional and exposure-based career motivations

Learners' reasons for selecting careers were largely emotionally driven, rooted in personal experiences, family influence, or admiration for public figures. Many learners aspiring to become doctors expressed caring values or referenced emotionally significant experiences. For example, of the six learners who said that they wanted to be medical doctors, five stated that they want to become doctors because they care about people, while one said that she had promised her dying grandfather that she would become a doctor one day. Another learner indicated that her choice of being a dermatologist was inspired by a television show and one who chose to be a gynaecologist explained that she simply "loves pregnant people." Others expressed admiration for family members working as mechanics, which influenced their choice of mechanical engineering despite the inaccurate understanding of the field. These motivations reveal a lack of research-based or knowledge-driven career exploration, reflecting the environmental limitations common in rural contexts. Very few learners grounded their choices in an understanding of academic requirements or the scientific nature of the fields they named. The absence of prior structured guidance leaves learners to rely on informal sources that shape choices that are often misaligned with STEM subject requirements and career realities.

Limited subject choice awareness and Grade 10 misconceptions

When asked about prospective Grade 10 subjects, only 12 of the 40 learners provided responses, and many demonstrated misunderstandings of the FET curriculum. For example, one learner responded, "I want to do maths, science, and technology", unaware that technology is not done in Grade 10, but what is on offer is a choice of technical subjects. Another learner stated that she wanted to take Life Science and Natural Science, also unaware that Life Science is part of Natural Science. Although some learners chose correct FET subjects, they lacked comprehensive information regarding the entire subject stream. Three learners stated that they wished to study mathematics but did not name any other disciplines that would accompany it. One stated that she wished to pursue history subjects. These misconceptions illustrate a weak

alignment between career aspirations and subject-choice knowledge, highlighting the absence of structured subject-choice guidance at a critical transition point.

Shifts in career knowledge and identity after the intervention

Following the career-awareness workshop, learners demonstrated substantial improvement in their knowledge of STEM careers and the academic pathways required to pursue them. More learners responded to the questions asked compared to the pre-intervention period. From a sample of 40 learners who participated in the study, 39 attended the career awareness program, and participated in the post-intervention focus group interviews. Table 2 shows a greater variance in career choices that included a STEM career before and after the career awareness intervention.

Table 2
Career choices before and after the Career Awareness Event

	Total Responses	**Career choice including a STEM subject**	**Career choice excluding a STEM subject**
Pre career awareness interviews	73	58%	41%
Post career awareness interviews	98	97%	18%
Variance	25	39%	23%

To ensure that learners submitted answers that matched the knowledge gained during the career awareness session, questions were posed about their post-career awareness decisions. The question on career knowledge was replaced by a question on how the career awareness influenced their career choice. Learners articulated clearer and more accurate explanations of STEM professions, including other careers such as aeronautical engineering, environmental science, and forensic analysis which were newly mentioned after exposure to the career booklet and presentations by STEM professionals.

Learners' STEM identity also strengthened, particularly through interactions with relatable role models. One learner[1] explained,

> I recall watching the video of the man who spoke about mechanical engineering because that is also the career that I want to pursue. He was the one who pushed me because I had reservations about my career choice because I am a woman, and I didn't think it was appropriate for me to pursue that type of work. But, as of that day, I discovered that I, too, am eligible for that position. In ten years, I picture myself continuing my chosen career and inventing machines.

[1] Participant responses have not been edited.

Another learner expressed renewed confidence after hearing a rural-born medical researcher discuss her journey from a similar background, stating that it made her "believe that I can be anything I want to be." Familiar family background, in addition to a rural place, motivated another student to choose and stay in the STEM subject stream. Her response to a question about her reasons for choosing a STEM career was,

> For me, it is that doctor who informed us that she is developing medicine for breast cancer. She told us that she grew up in a rural area with a single parent and a low income. I had given up on becoming successful because I am from a remote location and was raised by a single mother.

These examples demonstrate a transition from identity uncertainty to identity recognition, a key component of STEM identity formation.

Transforming career motivations: From emotion to purpose

Post-intervention, learners' motivations for selecting careers shifted from emotional or aspirational choices to more purpose-driven and community-oriented reasoning. Learners articulated a desire to contribute to addressing local problems in their rural communities such as improving hospital accessibility, reducing water scarcity, and supporting affordable healthcare, this showing a deeper understanding of how STEM careers intersect with societal needs. We cite three learners' responses to a question based on the reasons for their career choices.

> L18: I'd like to become a doctor. To go study and then return to rural areas since I've witnessed a shortage of service delivery in local hospitals. It normally takes time to reach someone who needs help the most, which is why I want to be a doctor because the hospitals here are rather far away, which eventually leads to death in rural regions because ambulances take time to arrive.

> L 24: For me, I want to be a chemist. I also want to help people who can't afford medical care, such as medicine, so that they can live longer. Medicine is expensive, and I want to help people in villages rather than just town people who can afford it. I want to help the people in the rural by creating a medical clinic.

> L 25: Our village is experiencing water problems. Some folks get unclean water, while others don't get any at all. So, that Doctor of Water (Environmental Scientist specialising in water analysis and treatment) inspired me to be like her someday because water is life. Without water in your body, you can get sick or anything, therefore I believe I could go out and learn about water before returning here to help with water.

This shift reflects a more mature and contextually grounded understanding of STEM careers, suggesting that the intervention not only enhanced knowledge but also deepened learners' sense of agency and purpose in STEM.

Increased confidence in STEM subject choices

After the intervention, all learners, including those who did not ultimately choose STEM careers, expressed an intention to take mathematics and physical science in Grade 10. Some still expressed fear or anxiety about perceived difficulty, but they now understood the importance of these subjects and felt encouraged by role-model stories and the clarity provided in the career booklet. The response of one learner regarding subject choice in the post intervention interviews was, "I'm going to study physics next year, but I'm frightened since people say it's difficult and that I'll switch to a different subject after a month."

Learners' post-intervention responses indicated a stronger awareness of the critical link between STEM subjects and STEM futures, reflecting enhanced competence and performance dimensions of STEM identity. Across both phases of data collection, a clear trajectory emerged. Before the intervention, learners had limited knowledge, misconceptions, emotional reasoning, and weak STEM identities. After the intervention, learners demonstrated greater confidence, improved accuracy in career and subject knowledge, stronger self-recognition as potential STEM participants, and more purposeful career intentions.

Discussion

The findings in this study reveal a clear developmental trajectory in how rural Grade 9 schoolgirls understand STEM careers and construct their STEM identities before and after a targeted career-awareness intervention. Prior to the intervention, most learners showed limited and often inaccurate knowledge of STEM careers and subject pathways. For example, conflating mechanical engineering with automotive repair or using the undifferentiated label "doctor-doctor" to refer to medicine, while others misidentified Grade 9 subjects as FET choices (e.g., "Natural Science" instead of "Life Sciences") or proposed combinations not available at Grade 10 (e.g., "technology"). Career rationales were largely emotionally-driven or exposure-driven (e.g., admiration for a relative, a promise to a family member, or inspiration from television), rather than grounded in accurate pathway knowledge. These patterns reflect constraints across the three identity components of Carlone and Johnson's (2007) STEM-identity framework.

- *Competence* (what learners know): misconceptions about careers/subjects indicate weak competence in navigating STEM pathways.
- *Performance* (how learners demonstrate/express what they know): difficulty articulating correct subject combinations or explaining career requirements reveals performance limitations in STEM discourse.
- *Recognition* (seeing and being seen as a "STEM person"): the reliance on emotional narratives amid uncertainty suggests fragile self-recognition in STEM and limited recognition from others (peers/teachers/media) as being STEM-capable.

The choice of non-STEM careers or a combination of STEM and non-STEM careers verifies the findings of Archer et al. (2020) and Kang et al. (2023) that a lack of understanding about science-related careers and goals can alter learners' interests, resulting in fewer learners

entering STEM careers. The observed inaccurate career knowledge and weak subject choice literacy also align with research linking limited career information to diminished STEM intentions among girls (see Archer et al., 2020; Blotnicky et al., 2018) and with evidence that Grade-level pathway knowledge is crucial before Grade 10 to 12 subject selection (Department of Basic Education, 2012).

Gendered beliefs that position science/technology as masculine undermine girls' confidence and belonging (Grimalt-Álvaro et al., 2025). In rural contexts, traditional gender roles and reduced exposure to role models further depress girls' STEM identification and aspirations, and amplify competence/performance/recognition gaps. According to Carlone and Johnson (2007), learners' incapacity to identify themselves as future STEM career professionals has a detrimental impact on their STEM identities and restricts prospects for STEM career advancement. In particular, this lack of self-recognition results in fragile STEM self-identification and reduces learners' preparedness to make informed decisions regarding STEM-related subjects and career pathways.

After the career-awareness workshop featuring rural-origin STEM professionals and a careers booklet, learners provided clearer, more accurate explanations of STEM professions (including newly surfaced careers such as aeronautical engineering, environmental science, and forensics), and linked careers to appropriate subjects. Learners articulated recognition shifts ("I discovered that I, too, am eligible for that position" and "I can be anything I want to be"), that signalled increased confidence and belonging in STEM. Crucially, learners reported intentions to take mathematics and physical science in Grade 10, even while acknowledging the perceived difficulty of physics, attributing their decisions to the workshop interactions and the booklet's clarity. The intervention appears to have strengthened competence by correcting misconceptions and expanding accurate career/subject knowledge, improved performance since learners could now articulate pathway-aligned choices and provide reasoned justifications rather than emotion-only narratives, activated recognition since contact with relatable role models had fostered self-recognition and a sense of belonging in typically male-dominated fields (e.g., engineering) as articulated by the STEM identity competencies (see Carlone & Johnson, 2007).

These shifts match evidence that exposure to role models and accurate pathway information strengthens STEM identity and participation (see Shin et al., 2016; Singer et al., 2020), and that embedded careers education enhances awareness and aspirations when timed with key schooling transitions (see Department of Basic Education, 2012; Kang et al., 2023). Moreover, the observed links between stronger identity and subject-choice intention are consistent with work connecting identity to persistence and STEM choice.

An important qualitative shift is the move from emotion-based motivations ("I care for people") to purpose-driven, community-oriented rationales (like water security and rural clinic access). This suggests not only improved knowledge but a deeper sense of agency and belonging that is core to the recognition dimension which aligns with literature underscoring belonging/self-efficacy as levers for girls' sustained engagement in STEM. Delivering identity-responsive career awareness before Grade 10 subject selection appears to nudge

intentions toward STEM pathways, precisely where policy and prior research recommend intervention (Makola et al., 2021). That such shifts followed a single, context-relevant exposure underscores the scalability of brief, well-designed interventions in rural settings.

Limitations and credibility

As a qualitative case study of two rural schools with 40 participants, findings are analytical rather than statistically generalisable. Translation and a short post-intervention window may have shaped how learners voiced changes. Nonetheless, ethical procedures were observed, data was audio-recorded and transcribed, and analysis followed Braun and Clarke's (2006) six-phase thematic analysis, with descriptive numbers used only to support qualitative patterns.

Conclusion and recommendations

This study demonstrates that rural schoolgirls enter Grade 9 with limited and often inaccurate knowledge of STEM careers and subject pathways and this constrains their STEM identities and career aspirations. These findings mirror national policy concerns since the Department of Basic Education (2012) requires Grade 9 learners to make informed subject selections that determine access to STEM pathways, yet many learners in this study lacked the required foundational guidance.

The pre-intervention misconceptions and emotionally driven choices align with existing literature showing that insufficient career information, gendered stereotypes, and restricted exposure disproportionately hinder girls' STEM trajectories (Archer et al., 2020; Grimalt-Álvaro et al., 2025). These barriers are further intensified in rural contexts, where opportunities for exposure are limited and traditional gender norms remain strong.

After the intervention, learners demonstrated improved career knowledge, stronger recognition of themselves as potential STEM participants, and clearer subject-choice intentions confirming the value of role model exposure and contextualised career information, as highlighted by Shin et al. (2016) and Singer et al. (2020). These shifts also align with global policy concerns articulated by the United Nations Educational, Scientific and Cultural Organization (2019) and the World Economic Forum (2021), both of which cite career awareness and role-model visibility as critical for addressing persistent gender gaps in STEM participation. The study confirms that identity-responsive, early career interventions can strengthen meaningfully rural girls' STEM identities and readiness for STEM subject choices.

To strengthen rural schoolgirls' STEM identities and support informed Grade 10 subject decisions, schools should institutionalise structured STEM career awareness in Grade 9, as required by the Department of Basic Education (2012) policy mandating informed subject-choice preparation before learners enter Grade 10. Such programmes should include rural-origin STEM role models consistently, since exposure to relatable professionals has been shown to challenge stereotypes and enhance learners' sense of belonging in STEM fields (Shin et al., 2016; Singer et al., 2020). In addition, schools should provide accessible, localised career-subject mapping resources, such as updated STEM career booklets, to help learners link

specific careers with Grade 10 to 12 subject requirements, as supported by Kang et al. (2023). Sustained identity-building opportunities, including STEM clubs, mentorship programmes, and community-based science activities, could complement once-off events to reinforce competence, performance, and recognition over time. These efforts align with the United Nations Educational, Scientific and Cultural Organization (2019) and the World Economic Forum (2021) recommendations that early, accurate career information and visible role models are essential for closing gender gaps in STEM participation globally and particularly in under-resourced rural contexts.

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References

Archer, L., Moote, J., MacLeod, E., Francis, B., & DeWitt, J. (2020). *ASPIRES 2: Young people's science and career aspirations*, *age 10–19.* UCL Institute of Education.

Blotnicky, K., Franz-Odendaal, T., French, F., & Joy, P. (2018). A study of the correlation between STEM career knowledge, mathematics self-efficacy, career interests, and career activities on the likelihood of pursuing a STEM career among middle school students. *International Journal of STEM Education*, *5*, 22. https://doi.org/10.1186/s40594-018-0118-3

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching*, *44*(8), 1187–1218. https://doi.org/10.1002/tea.20237

Department of Basic Education . (2012). *National policy pertaining to the programme and promotion requirements of the National Curriculum Statement Grades R–12.* www.education.gov.za/Portals/0/Documents/Policies/PolicyProgPromReqNCS.pdf

Grimalt-Álvaro, C., Valls, C., Cebrián, G., & Marqués-Molías, L. (2025). An exploration of students' attitudes towards STEM and climate change: A cluster analysis study with a gender perspective. *European Journal of STEM Education*, *10*(1), 02. https://doi.org/10.20897/ejsteme/16206

Grogan, K. E. (2019). How the entire scientific community can confront gender bias in the workplace. *Nature Ecology & Evolution*, *3*(1), 3–6. https://doi.org/10.1038/s41559-018-0747-4

Kang, J., Salonen, A., Tolppanen, S., Scheersoi, A., Hense, J., Rannikmäe, M., & Keinonen, T. (2023). Effect of embedded careers education in science lessons on students' interest, awareness, and aspirations. *International Journal of Science and Mathematics Education*, *21*(1), 211–231. https://doi.org/10.1007/s10763-021-10238-2

Makarova, E., Aeschlimann, B., & Herzog, W. (2019). The gender gap in STEM fields: The impact of the gender stereotype of math and science on secondary students' career aspirations. *Frontiers in Education*, 4, 60. https://doi.org/10.3389/feduc.2019.00060

Makola, Z., Saliwe, P., Dube, I., Tabane, R., & Mudau, A. (2021). High school learners' views on benefits derived from attending career talks: Need for sound career guidance. *The Journal for Transdisciplinary Research in Southern Africa*, *17*(1), a1082. https://doi.org/10.4102/td.v17i1.1082

McNeill, F., & Wei, L. (2025). Encouraging young women into STEM careers: A study comparing career intention of female STEM students in China and Scotland. *Journal for STEM Education Research*, *8,* 30–58. https://doi.org/10.1007/s41979-023-00114-9

Msambwa, M. M., Daniel, K., Lianyu, C., & Anthony, F. (2025). A systematic review using feminist perspectives on the factors affecting girls' participation in STEM subjects. *Science & Education*, *34*, 1619–1650. https://doi.org/10.1007/s11191-024-00524-0

Sáinz, M., Martínez-Cantos, J. L., & Meneses, J. (2020). Gendered patterns of coping responses with academic sexism in a group of Spanish secondary students. *International Journal of Social Psychology*, *35*(2), 246–281. https://doi.org/10.1080/02134748.2020.1721049

Shin, J. E. L., Levy, S. R., & London, B. (2016). Effects of role model exposure on STEM and non-STEM student engagement. *Journal of Applied Social Psychology*, *46*(8), 410–427. https://doi.org/10.1111/jasp.12371

Singer, A., Montgomery, G., & Schmoll, S. (2020). How to foster the formation of STEM identity: Studying diversity in an authentic learning environment. *International Journal of STEM Education*, *7,* 57. https://doi.org/10.1186/s40594-020-00254-z

U.S. Census Bureau. (2022). American Community Survey 5 Year Estimates: Rural and urban definitions. https://www.census.gov/about/policies/citation.html

U.S. Department of Education. (2025). Rural Education Resource Center. https://www.ed.gov/about/initiatives/rural-education-resource-center

United Nations Educational, Scientific and Cultural Organization. (2019). *Women in science*. https://unesdoc.unesco.org/ark:/48223/pf0000370742

World Economic Forum. (2021). *Why we need more girls in Africa in STEM – and how to get them.* Education and Skills. https://www.weforum.org/stories/2021/04/women-stem-africa-science-gender-education-tech/

Yin, R. K. (2012). Designing case studies. In L. Maruster & M. J. Gijsenberg (Eds.), *Qualitative research methods* (pp. 359–386). SAGE.

Zadawa, A. N., & Omran, A. (2020). Rural development in Africa: Challenges and opportunities. In A. Omran & O. Schwarz-Herion (Eds.), *Sustaining our environment for a better future* (pp. 33–42). Springer. https://doi.org/10.1007/978-981-13-7158-5_3