

Gendered Pathways to STEM Careers among Rwandan Adolescents

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Abstract

Increasing participation in science, technology, engineering, and mathematics (STEM) requires understanding students' aspirations and the experiences and social influences shaping their educational and career pathways. This study examined STEM aspirations among secondary school students in Rwanda, focusing on gender, STEM-related experiences, role-model exposure, and perceived barriers. A cross-sectional survey was conducted among 859 secondary school students in Rwanda. Data were analysed using descriptive statistics, Mann–Whitney U tests, Pearson's chi-square tests, and Spearman's rank-order correlations. Students reported high STEM interest ($M = 4.39$, $SD = 0.94$), perceived importance of STEM skills ($M = 4.55$, $SD = 0.81$), STEM career intention ($M = 4.42$, $SD = 0.89$), and confidence in succeeding in STEM careers ($M = 4.44$, $SD = 0.84$). Female students reported significantly greater perceived importance of STEM skills than males ($p = .009$). Gender was significantly associated with university STEM study intention ($\chi^2(2) = 7.42$, $p = .024$) and STEM career intention ($\chi^2(4) = 14.03$, $p = .007$). STEM experiences were positively associated with career intention ($\rho = .208$, $p < .001$), while role-model exposure showed a modest positive association ($\rho = .138$, $p < .001$). Lack of role models or representation was the most frequently reported barrier and differed significantly by gender ($\chi^2 = 5.35$, $p = .021$). Rwandan secondary students demonstrated strong STEM aspirations, particularly female students, despite limited STEM experiences and concerns about representation. Strengthening authentic STEM experiences, career guidance, and sustained access to diverse STEM role models may help translate these aspirations into sustained and equitable STEM educational and career pathways.

1. Introduction

Science, technology, engineering and mathematics (STEM) play an increasingly important role in economic development, innovation and preparation of young people for rapidly changing labour markets. However, women and girls remain underrepresented in several STEM fields, particularly engineering, computing and some physical sciences (Durrani & Kataeva, 2025; Khodjaev, et al., 2026). Gender disparities are shaped not only by access to education but also by students' experiences, perceptions of competence, social expectations and the extent to which STEM environments are perceived as inclusive and attainable (Cheryan et al., 2025). Understanding how these factors develop during adolescence is therefore important because this is a period when students increasingly form educational and occupational aspirations.

During secondary education, young people increasingly develop expectations about their future studies and occupations and begin making educational decisions that may shape subsequent pathways. However, many adolescents do not receive sufficient opportunities to explore careers, interact with professionals or understand the pathways linking school learning to employment. The OECD's recent analysis of teenage career preparation indicates that career uncertainty is widespread and that many young people have limited access to career-development activities that connect them with employers and people in work (Kayan-Fadlelmula et al., 2022; OECD 2025). UNESCO's recent work emphasizes the importance of quality STEM learning, supportive teachers, mentorship, visible role models and

interventions that challenge gender stereotypes in promoting girls' participation in STEM (UNESCO, 2017; UNESCO, 2024).

STEM aspirations are closely related to students' beliefs about their own capabilities. Self-efficacy, or confidence in one's ability to perform STEM-related tasks, is an important motivational factor associated with STEM interests and career intentions. Recent evidence shows that STEM self-efficacy is positively associated with students' STEM career interests and that gender differences may exist in both self-efficacy and career interests (Jiang et al., 2024). Similarly, students' perceptions of STEM professionals and their own STEM self-concept can influence the extent to which STEM learning opportunities translate into career aspirations (Chen et al., 2024). Examining both aspirations and self-efficacy is therefore important for determining whether girls and boys perceive STEM careers as equally desirable and attainable (Jiang et al., 2024; Yamani & Almazroa, 2024).

Students' STEM aspirations are also influenced by the opportunities they encounter during their education. Experiences such as science fairs, experiments, science clubs, museum visits and interactions with STEM professionals can provide opportunities for students to experience STEM beyond routine classroom instruction and to develop more informed perceptions of STEM careers. Chen et al. (2024) found that school-based STEM learning opportunities were associated with career aspirations through students' perceptions of STEM professionals, with this relationship depending partly on students' STEM self-concept. Role models may similarly influence students' perceptions of who can succeed in STEM and whether STEM careers are personally attainable. Thus, examining students' exposure to STEM experiences and role models can provide insight into how educational and social environments are associated with STEM career intentions (Chen et al., 2024; Gao et al., 2025).

Gender stereotypes constitute another potential barrier to STEM participation (Msambwa, et al. 2025). Adolescents may encounter messages suggesting that boys are naturally more capable in mathematics, technology, engineering or physical sciences, while girls are better suited to other areas. A large preregistered meta-analysis of 98 studies involving more than 145,000 children and adolescents across 33 countries found that gender stereotypes concerning STEM abilities develop across childhood and adolescence, although their strength varies considerably across STEM domains (Miller et al., 2024). Such stereotypes can contribute to perceptions that STEM is difficult, masculine or unsuitable for girls, potentially affecting confidence, belonging and career intentions (Chen, et al. 2024). Consequently, increasing girls' participation in STEM requires more than encouraging them to develop an interest in science. It also requires supportive educational environments, opportunities to encounter STEM professionals, access to role models and interventions that enable students to translate aspirations into realistic educational and career pathways. The visibility of appropriate role models may also matter because students' perceptions of STEM professionals can influence whether STEM careers are viewed as desirable and attainable (Chen, et al. 2024; Miller et al., 2024; Msambwa et al., 2025).

These issues are particularly relevant in Rwanda, where STEM education is central to national development and efforts to expand opportunities for young people. Nevertheless, gender differences in

STEM perceptions and participation remain an important concern. Evidence from Kayonza District showed gender differences in STEM interests, competency self-beliefs and attitudes among 915 secondary school students. Although girls were no less eager than boys to pursue formal-sector employment, differences in self-beliefs and the persistence of traditional gender stereotypes remained important challenges (Wuyts, et al., 2022; Andersen, 2023). More recently, Gao et al. (2025), examining the perspectives of 409 Rwandan secondary school students, found that students generally valued STEM education and expressed diverse future aspirations, while also highlighting the importance of supportive teachers, adequate resources and career guidance. The study further identified gender norms and the availability of female role models as relevant concerns for girls' engagement with STEM. However, there is limited context-specific evidence on how Rwandan secondary school students perceive STEM careers and how gender, family, teachers, exposure to STEM opportunities, role models and perceived barriers shape these aspirations (Gao et al., 2025; Wuyts et al., 2022).

The survey provides an important opportunity to examine whether girls and boys differ in their STEM aspirations and perceptions and, importantly, whether strong aspirations coexist with barriers that may constrain future participation. The results are particularly relevant because the sample was predominantly drawn from rural schools, providing evidence from a population that may have different opportunities for STEM exposure and career exploration than students in more urban settings. The study therefore moves beyond the question of whether adolescents are interested in STEM to examine the social, educational and gender-related conditions surrounding STEM aspirations. This study was guided by the following objectives:

1. To assess secondary school students' STEM aspirations and confidence, and examine gender differences in STEM educational and career intentions.
2. To examine the association between students' exposure to STEM experiences, STEM role models, and their intentions to pursue STEM careers.
3. To identify gender differences in perceived barriers to STEM careers, with particular attention to perceived difficulty, role-model representation, and gender stereotypes.

2. Methods

2.1 Study design and setting

A cross-sectional quantitative survey design was used to examine STEM career aspirations among secondary school students in Rwanda, with particular attention to gender differences, STEM-related experiences, and exposure to STEM role models. The design was appropriate because the study sought to describe students' STEM aspirations and examine statistical associations between students' characteristics, experiences, social influences, and career intentions at a particular point in time.

2.2. Study population and participants

The study population comprised secondary school students in Rwanda. The sample comprised 859 students, including 576 females (67.1%) and 279 males (32.5%). Three students (0.3%) preferred not to report their gender, while gender information was missing for one student (0.1%). Most participants were aged 14–17 years (51.80%). Students with disabilities were also represented, accounting for 105 (12.22%) participants. The sample was predominantly drawn from rural schools (734, 85.45%), while 125 (14.55%) participants were from urban schools. Geographically, most participants were from the Eastern Province (65.77%) and Western Province (33.99%), with limited representation from the Southern Province. Participation was based on students' availability and willingness to complete the survey. Only responses meeting the predefined requirements for inclusion in the analysis were retained. Therefore, the findings are interpreted as reflecting the study sample rather than as nationally representative estimates. Data were collected between May and July 2025.

2.3. Data collection instrument

Data were collected using a structured, self-administered questionnaire designed to assess students' perceptions, experiences, and aspirations related to STEM education and careers. The questionnaire covered several domains, including STEM interest and attitudes, perceived importance of STEM skills for future employment, confidence in succeeding in STEM careers, intention to study STEM at university, intention to pursue a STEM career, exposure to STEM-related experiences, and exposure to STEM role models. Most attitudinal and aspiration items were measured using five-point response scales ranging from low to high levels of agreement, interest, confidence, or intention.

STEM-related experiences were assessed based on students' reported exposure to activities such as participating in science fairs, visiting science museums, conducting science experiments inside and outside school, and seeing a scientist in real life. Exposure to STEM role models was assessed through students' reports of whether they had connections with people working in STEM fields, including a relative, a family friend, a woman, or a man working in a STEM-related field.

2.4. Study variables

The primary outcome variable was STEM career intention, measured on a five-point scale ranging from *not likely at all* to *very likely*. Three groups of explanatory variables corresponded to the study objectives. Gender was examined in relation to university STEM study intention and STEM career intention. STEM-related experiences were also examined as potential experiential correlates of STEM career intention. Finally, STEM role-model exposure was examined as a social influence associated with STEM career intention.

A composite STEM-experience score was generated from students' reported exposure to the selected STEM experiences. Similarly, a STEM role-model exposure score was calculated by counting the number of different types of STEM role-model connections reported by each student, producing a score ranging from 0 to 4.

2.5. Statistical analysis

Data were analysed using descriptive and inferential statistics appropriate to the nature and measurement level of the variables. Categorical variables were summarised using frequencies and percentages, while five-point STEM aspiration and career-intention measures were described using means and standard deviations.

Gender differences in ordinal STEM aspiration and confidence measures were assessed using the Mann-Whitney U test, while associations between gender and categorical STEM educational and career intentions were examined using Pearson's chi-square (χ^2) test. Associations between STEM-related experiences, STEM role-model exposure, and STEM career intention were assessed primarily using Spearman's rank-order correlation (ρ), given the ordinal nature of the measures. Pearson's χ^2 test was additionally used as a complementary analysis where appropriate.

Perceived barriers to STEM participation were examined descriptively and, where relevant, compared by gender using χ^2 tests. All tests were two-tailed, with statistical significance set at $p < .05$. Given the cross-sectional design, significant findings were interpreted as associations rather than causal effects.

3. Results

3.1 STEM aspirations, confidence, and gender differences in educational and career intentions

The study included 859 secondary school students, comprising 576 females (67.1%) and 279 males (32.5%); three students (0.3%) preferred not to report their gender and one response was missing. Overall, students reported high levels of STEM interest, perceived importance of STEM skills, STEM career intention, and confidence in succeeding in STEM careers.

3.1.1 STEM aspirations and confidence

STEM interest was high overall ($M = 4.39$, $SD = 0.94$), as was the perceived importance of STEM skills for future employment ($M = 4.55$, $SD = 0.81$). Students also reported high likelihood of considering a STEM career ($M = 4.42$, $SD = 0.89$) and high confidence in succeeding in a STEM career ($M = 4.44$, $SD = 0.84$).

Table 1
STEM aspirations and career confidence by gender

STEM measure	Overall M ± SD	Female M ± SD	Male M ± SD	p-value
Interest in STEM subjects	4.39 ± 0.94	4.41 ± 0.94	4.35 ± 0.94	.253
Importance of STEM skills for future jobs	4.55 ± 0.81	4.59 ± 0.80	4.48 ± 0.83	.009
Likelihood of considering a STEM career	4.42 ± 0.89	4.44 ± 0.90	4.37 ± 0.88	.054
Confidence in succeeding in a STEM career	4.44 ± 0.84	4.46 ± 0.86	4.42 ± 0.80	.190

M = mean; SD = standard deviation.

Table 1 indicates that female students rated the importance of STEM skills significantly higher than male students ($M = 4.59$ vs. 4.48 , $p = .009$). However, there were no statistically significant gender differences in STEM interest ($p = .253$), likelihood of considering a STEM career ($p = .054$), or confidence in succeeding in a STEM career ($p = .190$).

3.1.2 Gender differences in educational and career intention

1. Gender differences in University STEM study intentions

Female students were more likely than male students to report a definite intention to study STEM at university (71.5% vs. 62.4%). In contrast, male students were more likely to report uncertainty, with 28.0% selecting “Maybe” compared with 20.5% of females. The significant chi-square result indicates that university STEM study intention was not distributed independently of gender.

Table 2
University STEM study intentions by gender

Intention to study STEM at university	Female, n (%)	Male, n (%)	Total, n (%)
Yes, I plan to study STEM	411 (71.5)	174 (62.4)	585 (68.5)
Maybe, I will study STEM	118 (20.5)	78 (28.0)	196 (22.9)
No / Other	46 (8.0)	27 (9.7)	73 (8.5)
Total	575 (100)	279 (100.0)	854 (100.0)
Pearson's $\chi^2(2) = 7.42$, $p = .024$			

Gender was significantly associated with students' intention to study STEM at university, $\chi^2(2) = 7.42$, $p = .024$. The analysis was based on 854 valid responses (575 females and 279 males) as indicated on

Table 2.

1. Gender differences in STEM career intention

Table 3
STEM career intention by gender

Likelihood of considering a STEM career	Female, n (%)	Male, n (%)	Total, n (%)
Very likely	382 (66.3)	160 (57.3)	542 (63.4)
Somewhat likely	98 (17.0)	77 (27.6)	175 (20.5)
Neutral	71 (12.3)	31 (11.1)	102 (11.9)
Not very likely	20 (3.5)	7 (2.5)	27 (3.2)
Not likely at all	5 (0.9)	4 (1.4)	9 (1.1)
Total	576 (100)	279 (100.0)	855 (100.0)
Pearson's $\chi^2(4) = 14.03$, $p = .007$			

Female students were more likely to report being very likely to consider a STEM career than male students (66.3% vs. 57.3%). The analysis was based on 855 valid responses (576 females and 279 males) as indicated on Table 3.

Conversely, male students were more likely to select "somewhat likely" (27.6% vs. 17.0%). Overall, the results indicate that female students did not have weaker STEM career aspirations; rather, they showed a greater concentration in the highest career-intention category. Gender was also significantly associated with STEM career intention, $\chi^2(4) = 14.03$, $p = .007$.

3.2 STEM experiences, STEM role-model exposure and career intentions

3.2.1 STEM experiences and career STEM intentions

Despite the high levels of STEM aspiration, students reported relatively limited exposure to several STEM-related experiences. Valid responses vary slightly across individual experience items because of missing responses (Table 4).

Table 4
STEM experiences and career STEM intentions association

STEM experience	Never, n (%)	Some exposure, n (%)	Spearman's ρ	p-value
Participated in a science fair	486 (56.6)	373 (43.4)	.163	< .001
Visited a science museum	524 (61.1)	333 (38.9)	.118	< .001
Science experiments in school	307 (35.7)	552 (64.3)	.203	< .001
Science experiments outside school	459 (53.5)	400 (46.5)	.115	< .001
Seen a scientist in real life	318 (37.0)	540 (63.0)	.174	< .001
Composite STEM-experience score	—	—	.208	< .001

More than half had never participated in a science fair (56.6%), visited a science museum (61.1%), or conducted science experiments outside school (53.5%). School-based experiments were more common, although 35.7% reported never having this experience.

All five STEM experiences were significantly and positively associated with STEM career intention. The strongest association was observed for school-based science experiments ($\rho = .203$, $p < .001$), followed by seeing a scientist in real life ($\rho = .174$, $p < .001$), participating in science fairs ($\rho = .163$, $p < .001$), visiting science museums ($\rho = .118$, $p < .001$), and conducting experiments outside school ($\rho = .115$, $p < .001$). The composite STEM-experience score also showed a significant positive association with career intention ($\rho = .208$, $p < .001$). These results indicate that students who reported greater exposure to STEM experiences tended to report stronger STEM career intentions.

3.2.2 STEM role-model exposure and career intention

Students reported varying levels of access to STEM role models. Overall, 51.6% reported having a relative working in STEM, 44.4% knew a family friend working in STEM, 59.3% personally knew a woman working in STEM, and 57.5% personally knew a man working in STEM.

Table 5
STEM role-model exposure and STEM career intention

Role-model exposure score	n	Mean career intention $\pm$ SD	Very likely, n (%)	Positive intention* n (%)
0	198	4.22 $\pm$ 0.95	101 (51.0)	149 (75.3)
1	93	4.39 $\pm$ 0.99	62 (66.7)	73 (78.5)
2	208	4.44 $\pm$ 0.89	133 (63.9)	183 (88.0)
3	122	4.45 $\pm$ 0.90	80 (65.6)	104 (85.2)
4	238	4.56 $\pm$ 0.76	168 (70.6)	209 (87.8)
Total	859	4.42 $\pm$ 0.89	544 (63.3)	718 (83.6)
Pearson's $\chi^2(16) = 34.62, p = .004$; Spearman's $\rho = .138, p < .001$				

Role-model exposure score was created by summing these four types of STEM connections, giving a possible range of 0–4. Greater exposure to STEM role models was modestly but significantly associated with stronger STEM career intentions ($\rho = .138, p < .001$). Mean career-intention scores increased from 4.22 (SD = 0.95) among students reporting no role-model connections to 4.56 (SD = 0.76) among those reporting four types of connections.

Mean career-intention scores increased from 4.22 (SD = 0.95) among students with no role-model exposure to 4.56 (SD = 0.76) among students reporting four types of STEM role-model connections. The proportion reporting the strongest career-intention category also increased from 51.0% among students with no role-model exposure to 70.6% among those with four types of connections. A supplementary analysis using positive versus neutral/negative career intention also showed a significant association with role-model exposure ($\chi^2(4) = 18.05, p = .001$).

3.3. Perceived barriers to STEM careers

Among female students, lack of role models or representation was the most frequently reported barrier (42.9%), followed by perceived difficulty of STEM subjects (39.8%) and gender stereotypes or biases (25.5%). Among male students, lack of role models or representation was also the most frequently reported barrier (51.6%), followed by perceived difficulty of STEM subjects (46.6%) and gender stereotypes or biases (25.1%).

Table 6
Perceived barriers to STEM participation by gender

Perceived barrier	Female n (%)	Male n (%)	χ^2	p-value
Perceived difficulty of STEM subjects	229 (39.8%)	130 (46.6%)	3.12	.078
Lack of role models/representation	246 (42.9%)	144 (51.6%)	5.35	.021
Gender stereotypes/biases	146 (25.5%)	70 (25.1%)	0.00	.969
Limited work-life balance	130 (22.6%)	69 (24.7%)	0.33	.565
Lack of awareness of STEM opportunities	170 (29.5%)	77 (27.6%)	0.30	.586

4. Discussion

4.1 Strong STEM aspirations and encouraging gender patterns

The present study demonstrates generally high levels of STEM interest, perceived importance of STEM skills, career intention, and confidence among secondary school students. This is encouraging because it indicates that STEM is positively perceived by a substantial proportion of students (Chen et al., 2024; Gao et al., 2025).

Most importantly, the findings challenge a simple assumption that female students have weaker STEM aspirations than male students. Female students were significantly more likely to rate STEM skills as important for future employment and were more likely to express a definite intention to study STEM at university. They were also more likely to report being very likely to consider a STEM career.

The significant association between gender and university STEM study intention ($\chi^2(2) = 7.42$, $p = .024$) showed that 71.5% of female students intended to study STEM at university compared with 62.4% of male students. Similarly, gender was significantly associated with STEM career intention ($\chi^2(4) = 14.03$, $p = .007$), with 66.3% of females compared with 57.3% of males reporting that they were very likely to consider a STEM career.

This finding is particularly relevant in the Rwandan context because recent research has also reported strong aspirations among Rwandan secondary students for professional and STEM-related futures. The present study therefore suggests that the challenge may not primarily be to generate STEM aspirations among girls, but rather to ensure that existing aspirations are successfully translated into STEM educational and occupational pathways (Gao, et al. 2025, Wuyts, et al. 2022).

The absence of a significant gender difference in career confidence is equally important. Female and male students reported similarly high confidence in succeeding in STEM careers. Thus, lower self-

confidence among girls does not appear to provide a sufficient explanation for gendered STEM participation in this sample (Jiang et al., 2024; Yamani & Almazroa, 2024).

4.2. The aspiration-experience gap

A notable finding was the coexistence of strong STEM aspirations with relatively limited exposure to authentic STEM experiences. More than half of students had never participated in a science fair, visited a science museum, or conducted science experiments outside school (Chen et al., 2024; Gao et al., 2025).

At the same time, all five STEM experiences were significantly and positively associated with STEM career intention. The strongest relationship was observed for school-based science experiments ($p = .203$, $p < .001$), while the composite STEM-experience score was also significantly associated with career intention ($p = .208$, $p < .001$).

Although the correlations are modest, their consistency across different types of experiences is noteworthy. The findings suggest that students who encounter STEM through practical, extracurricular or real-world experiences tend to report stronger career intentions.

One possible explanation is that experiential STEM activities allow students to see STEM as more than an abstract collection of school subjects. Practical investigations, science fairs, museum visits and encounters with scientists can provide opportunities for exploration, problem-solving and discovery, while also helping students understand what STEM professionals actually do (Chen et al., 2024; Gao et al., 2025).

Recent research has similarly shown that STEM learning opportunities and perceptions of STEM professionals are related to students' STEM career aspirations. Evidence from Rwanda also emphasises the importance of meaningful STEM learning experiences, resources and career guidance for students' future aspirations (Gao, et al. 2025).

Nevertheless, because this study is cross-sectional, the observed relationships should not be interpreted as evidence that STEM experiences cause stronger career intentions. Students with pre-existing STEM aspirations may themselves be more likely to seek out STEM experiences. Longitudinal and intervention studies are therefore needed.

4.3 Role models and STEM career intentions

The relationship between STEM role-model exposure and career intention provides another key finding. Students with broader exposure to STEM role models had significantly different career-intention distributions ($\chi^2(16) = 34.62$, $p = .004$), and the ordinal analysis confirmed a positive association ($p = .138$, $p < .001$). Mean career intention increased from 4.22 among students with no role-model exposure to 4.56 among those reporting four types of STEM role-model connections. (Chen et al., 2024; Tal et al., 2024).

This pattern suggests that access to STEM professionals may contribute to students' ability to imagine STEM careers as realistic and attainable futures. Relatives, family friends, women and men working in STEM can provide students with information about STEM occupations and demonstrate that such careers are achievable. The social environment surrounding adolescents also plays a significant role (Mulvey, et al. 2022). Parents and other family members can influence young people's perceptions of the value and attainability of STEM careers, while teachers can shape students' interest, confidence, classroom participation and sense of belonging. Exposure to STEM professionals and authentic STEM activities can further help students understand what STEM careers involve and envision themselves within those careers (Chen et al., 2024; Mulvey, et al. 2022; Tal et al., 2024).

The finding is particularly compelling when considered together with the perceived-barrier results. Lack of role models or representation was the most frequently reported barrier, while greater role-model exposure was associated with stronger career intention. The two findings therefore point in the same direction: social visibility and access to STEM professionals may be a central component of students' STEM career pathways (Wuyts, et al. 2022; Tal et al., 2024; Cheryan et al., 2025).

This supports the potential value of structured mentoring, STEM career talks, school–university partnerships, workplace visits, alumni programmes and sustained interaction with STEM professionals (Tal et al., 2024; Gao et al., 2025).

4.4 Representation as an important perceived barrier

Lack of role models or representation was the most frequently reported barrier and the only barrier that differed significantly by gender. It was reported by 42.9% of female students and 51.6% of male students ($\chi^2 = 5.35$, $p = .021$).

In contrast, gender stereotypes or biases were reported at almost identical levels among female and male students (25.5% vs. 25.1%, $p = .969$). This finding provides a more nuanced picture of gender and STEM participation. Rather than demonstrating that girls simply experience greater explicit gender stereotyping, the findings suggest that visibility and representation may be particularly important aspects of the STEM environment (Cheryan et al., 2025; Miller et al., 2024).

The survey also identified differences in perceived barriers. Among girls, the most frequently reported barriers were perceived difficulty (21.66%), lack of role models (17.50%) (Verdugo-Castro & Sánchez-Gómez 2023), and gender stereotypes (9.88%). Among boys, lack of role models (27.60%) and perceived difficulty (20.07%) were the most frequently reported barriers. These patterns reflect broader literature showing that while female students may possess strong aspirations, structural hurdles such as limited female mentorship and lingering socio-cultural stereotypes continue to act as key friction points (Ertl & Paechter 2017; Guo, et al. 2018). These findings suggest that high STEM aspirations among girls do not necessarily eliminate the social and structural perceptions that may affect their future STEM participation.

This does not mean that gender stereotypes are unimportant. Rather, students may encounter gendered STEM barriers through broader mechanisms, including who they see working in STEM, who they interact with, and whether STEM professionals appear socially and personally accessible. The result is especially relevant given the strong STEM aspirations reported by female students. If girls already aspire strongly to STEM, increasing the visibility of successful STEM professionals and providing direct opportunities to interact with them may be more productive than interventions focused exclusively on changing attitudes (Cheryan et al., 2025; Msambwa et al., 2025).

4.5 Implications for STEM education in Rwanda

The findings suggest that Rwanda faces less of an aspiration problem than an aspiration-to-pathway problem. Students demonstrated strong STEM aspirations, including female students, but many had limited opportunities to experience STEM outside conventional classroom settings. Greater exposure to STEM experiences and role models was associated with stronger career intentions. Three practical implications follow (Gao et al., 2025; Wuyts et al., 2022).

- Schools should expand authentic STEM experiences, including science fairs, practical experiments, STEM clubs, project-based learning, museum and university visits, and extracurricular STEM activities.
- Schools and education stakeholders should establish structured STEM role-model and mentoring programmes. These should include diverse STEM professionals and provide repeated interaction rather than relying solely on one-off motivational talks.
- Career guidance should connect STEM learning with concrete educational and occupational pathways. Students need to understand not only that STEM is important, but also how secondary-school STEM subjects connect to university programmes and future careers.

These strategies could be particularly valuable because the present data suggest that students already possess substantial STEM motivation. The goal should therefore be to strengthen the environments and opportunities through which this motivation can be converted into sustained STEM participation (Gao, Carter, Kwok, Shima, & Singa, 2025); OECD, 2025).

4.6. Strengths and limitations

This study has several strengths. First, it draws on a relatively large sample of 859 secondary school students, allowing gender comparisons and examination of several dimensions of STEM aspiration and exposure. Second, the study considers STEM aspirations alongside experiential and social influences, rather than examining interest or career intention in isolation. Third, the analysis distinguishes between general barriers and barriers that differ by gender, providing a more nuanced understanding of students' perceptions.

Several limitations should nevertheless be acknowledged. The cross-sectional design prevents causal conclusions regarding the relationships between STEM experiences, role models and career intentions. Second, the measures were self-reported and may therefore be subject to recall or social-desirability

bias. Third, because the available data do not establish probability-based national sampling, the findings should not be interpreted as nationally representative of all Rwandan secondary school students. Finally, STEM career intention is an attitudinal measure and does not necessarily translate into actual university enrolment, persistence or occupational entry.

Future research should therefore use longitudinal designs to examine whether STEM experiences and role-model exposure predict subsequent STEM subject selection, university enrolment and career persistence. Intervention studies could also test whether sustained mentoring, practical STEM experiences and career guidance produce measurable changes in students' STEM trajectories.

5. Conclusions

Taken together, the findings provide an encouraging but nuanced picture of STEM career development among Rwandan secondary school students. Students reported high STEM interest, high perceived value of STEM skills, strong career intentions and high confidence. Female students were particularly encouraging in this regard, showing stronger definite intentions to study STEM at university and a higher proportion reporting the strongest level of STEM career intention.

However, strong aspirations existed alongside relatively limited STEM experiences. At the same time, greater STEM experience and broader role-model exposure were consistently associated with stronger career intentions. The study therefore suggests that the central challenge is not simply to make students interested in STEM. Rather, the priority is to create conditions that enable students to act on their existing aspirations.

The combination of practical STEM experiences, visible and accessible role models, supportive learning environments and effective career guidance may provide an important pathway for converting strong adolescent STEM aspirations into sustained STEM education and careers (Chen et al., 2024; Gao et al., 2025; Tal et al., 2024).

Declarations

Ethics approval

The study protocol and research procedures were reviewed, authorized, and granted research approval/permit by the National Council for Science and Technology (NCST) in Rwanda (Ref No: NCST/482/0133/2025), in accordance with regulations of the Executive Secretary No: 001/NCST/2024 governing research in Rwanda (Official Gazette Special of 12/11/2024). Additional institutional recommendations and clearances were granted by the Rwanda Basic Education Board (REB) (Ref No: 2237/REB/01/2025) and the Rwandan Association for Women in Science and Engineering (RAWISE).

Consent to participate

Informed consent was obtained from all individual participants included in the study prior to data collection. For minor participants (secondary school students under 18 years of age), approval was obtained from the students in addition to parental/institutional consent facilitated through participating school heads. Participation was completely voluntary, and all participants were informed of their right to withdraw from the study at any time without penalty. Full confidentiality and anonymity of all participant responses were strictly maintained throughout data collection and analysis

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Clinical trial number

Not applicable.

Data availability

The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request, subject to applicable ethical, institutional, and confidentiality requirements.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Umumararungu, Marie Grace: Conceptualization, investigation, data collection, data analysis, report preparation, manuscript drafting, critical revision, and approval of the final manuscript.

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Mukanyiligira, Didacienne: Investigation, data collection, data analysis, report preparation, manuscript drafting, critical revision, and approval of the final manuscript.

Ukundimana, Zubeda: Contribution to report preparation, manuscript development, interpretation of the findings, critical revision of the manuscript for important intellectual content, and approval of the final manuscript.

Mukaneza, Delphine: Contribution to manuscript development, interpretation of the findings, critical revision of the manuscript for important intellectual content, and approval of the final manuscript.

Mbonyirivuze, Agnes: Coordination of manuscript preparation, data analysis, interpretation of the findings, manuscript drafting, critical revision, coordination of the final manuscript, submission coordination, and approval of the final manuscript.

Nyirahafashimana, Valentine: Contribution to manuscript development, interpretation of the findings, critical revision of the manuscript for important intellectual content, and approval of the final manuscript.

Sanga, Pascaline: Contribution to manuscript development, interpretation of the findings, critical revision of the manuscript for important intellectual content, and approval of the final manuscript.

Dushimirimana, Elyse: Contribution to the intellectual review and critical revision of the manuscript, substantive comments on the interpretation and presentation of the findings, and approval of the final manuscript.

All authors approved the final version of the manuscript and agree to be accountable for all aspects of the work, including ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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