frontiers | Frontiers in Education

TYPE Original Research
PUBLISHED 01 October 2025
DOI 10.3389/feduc.2025.1611178

OPEN ACCESS

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RECEIVED 13 April 2025
ACCEPTED 29 August 2025
PUBLISHED 01 October 2025

CITATION
Dogaru M, Negreanu MC, Pisică O and Pîrvu AF (2025) STEM career: essential factors for students to achieve success in STEM (supportive individuals, skills/abilities, motivational factors).
Front. Educ. 10:1611178.
doi: 10.3389/feduc.2025.1611178

STEM career: essential factors for students to achieve success in STEM (supportive individuals, skills/abilities, motivational factors)

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In Romania, where STEM enrollment stands at 26% of tertiary students compared to the EU average of 32%, understanding the factors that sustain student engagement is critical. This mixed-methods study examines motivations, wellbeing, and gender stereotypes shaping STEM success among 548 students at a technical university from Bucharest. Through literature review, questionnaires, and interviews, analyzed via inferential statistics and thematic coding, findings reveal that intrinsic motivation (34.74%) and career opportunities (36.16%) drive major choices, 71.39% associate STEM engagement with enhanced wellbeing, and 42.8% perceive gender stereotypes, with girls reporting greater impact. Triangulated data highlight the need for mentorship, digital resources, and inclusive policies to support Romania's STEM aspirations. Limited to one institution, this study offers insights for educators and policymakers to foster equitable STEM education.

KEYWORDS

STEM success, STEM motivation, STEM wellbeing, STEM gender stereotypes, Romanian STEM education

1 Introduction

For a Romanian girl student dreaming of engineering, STEM is a world of possibility—yet it's also a maze of late-night study sessions, whispers of "girls don't belong here," and the weight of a future that feels both thrilling and daunting. In Romania, where only 26% of university students pursue STEM fields compared to the EU's 32% (European Commission, 2023). Given the often-overburdened centralized education system, particularly in rural areas where 30% of our students reside, and the pervasive influence of cultural biases, what motivates these students? What keeps them going, and what threatens to dim their spark?

While global research paints a broad picture of STEM success, Romania's unique challenges—low enrollment, rural resource gaps, and persistent stereotypes—remain underexplored, overshadowed by Western studies (Luo et al., 2021; Darrah et al., 2022). Our study steps into this gap, exploring what motivates 548 STEM students at the technical university from Bucharest, how their studies shape their wellbeing, and whether gender stereotypes block their path. Using a blend of surveys and interviews approved by our university, we define STEM success as sticking the course, finding joy in the journey, and rising above biases, ensuring every voice was heard willingly and safely. STEM success is defined as a student's ability to thrive in STEM by continuing their studies (persisting in their major despite challenges), maintaining emotional and mental health (finding fulfillment and managing stress), and overcoming gender stereotypes (pushing past biases to pursue goals confidently).

This study poses three research questions:

- What motivates Romanian students to select STEM majors?
- How is engagement in STEM studies associated with their wellbeing?
- How do gender stereotypes influence their STEM aspirations?

By focusing on student experiences rather than workplace outcomes, and clarifying STEM as a disciplinary framework rather than a pedagogical model (Wieselmann et al., 2021), this research offers novel insights to inform Romanian STEM education policy and practice.

2 Literature review

This review combines research from around the world and Romania to explore the reasons, wellbeing, and challenges with stereotypes that 548 students, using Social Cognitive Career Theory (SCCT; Lent et al., 1994) and the Expectancy-Value Model (Eccles, 2009) as a guide. These viewpoints are linked by SCCT and EVM, which focus on three main ideas: why students choose STEM (for example, intrinsic motivation and career utility, according to EVM's value component), the link to wellbeing (e.g., emotional resilience, burnout prevention, and mental health benefits in high-pressure settings like Romania's STEM programs), and the effect of gender stereotypes (e.g., barriers that lower expectations for women). EVM especially helps us understand wellbeing by showing us the costs (like the emotional strain of stereotypes) and the benefits (like achieving something through hard work). SCCT, on the other hand, connects self-efficacy to social influences, giving us a complete picture of why people stick with STEM.

The Expectancy-Value Model (EVM; Eccles, 2009) enhances the Social Cognitive Career Theory (SCCT) by emphasizing two essential elements that affect individuals‘ career choices and persistence: expectancy, denoting the belief in one's ability to succeed in a task, and value, which includes the personal importance assigned to the task, such as intrinsic interest, utility for future goals, attainment value, and related costs like emotional or opportunity sacrifices. This study demonstrates that EVM clarifies the analysis by illustrating how students' perceived value of STEM, particularly career opportunities as a utility value, sustains motivation (Q1), enhances wellbeing by alleviating costs such as burnout (Q2), and interacts with gender stereotypes that may diminish expectations for female students (Q3). SCCT and EVM collaborate to provide two distinct perspectives: SCCT examines self-efficacy and environmental influences, whereas EVM focusses on motivational valuations. This enables a comprehensive examination of STEM persistence in Romania.

Three thematic areas-efficacy and STEM identity, social influences and equity, and educational interventions—provide a structured foundation for this study.

2.1 Career opportunities in STEM fields

2.1.1 The social perspective of defining a STEM career

STEM careers are cultural, social, and gender-shaped social environments. Gender dynamics and social circumstances influence students' STEM career preferences. STEM self-efficacy and interest are negatively affected by societal preconceptions (Luo et al., 2021; Casto, 2022; Chan and Cheung, 2018). These attitudes perpetuate social inequality. STEM job decisions are influenced by society utilitarian and success values. The desire to help others (a social value) influences job choices, yet the fear of adhering to a social group (a social norm) may lead to professional rejection (Rosenzweig et al., 2024). Parents, instructors, and community role models strongly influence young girls' STEM career choices (Zhao et al., 2023; Ali et al., 2018; Iroaganachi et al., 2021; McNeill and Wei, 2023). This shows that role models—real or fictional—influence STEM identity development. Students' STEM identity and perceptions of STEM careers depend on education quality and methodology, including teaching methods and school resources (Chen et al., 2024a,b,c; Halawa et al., 2024). The educational environment affects STEM job prospects. For equality, STEM fields must provide inclusive environments that foster a sense of belonging for all social groups, including women and minorities (McCrory, 2022; Lin et al., 2024; Rosenzweig et al., 2024).

Theories and models encompassing social dimensions differ. The Social Cognitive Career Theory (SCCT) is a psychological framework that analyzes the influence of social circumstances on self-efficacy and outcome expectations, which subsequently inform career decisions. The Theory of Vocational Development posits that social circumstances, socioeconomic status, and opportunity shape career development. The Transformative Activist Agency Model posits that individuals function as both professional agents and social actors capable of altering societal structures and norms (McCrory, 2022).

2.1.2 The psychological perspective of defining a STEM career

STEM identity, defined as a student's self-perception as a "STEM person", is a significant predictor of goals for a future in STEM fields (Zhao et al., 2023; Dou et al., 2019). STEM self-efficacy, defined as the confidence in one's capability to excel in mathematics and sciences, affects goals and understanding of STEM career prerequisites (Kelly et al., 2025; Zhao et al., 2023). A fervor for STEM disciplines and principles of utility and achievement, such as aiding others, propel interest in these domains; nevertheless, social integration challenges may impede progress (Chen et al., 2024a,b,c; Rosenzweig et al., 2024). The allure of mathematics appears to outweigh the anxiety that predominantly affects men's decision-making (Ferdinand et al., 2024). Perceptions of teacher quality and STEM opportunities in educational institutions influence job aspirations (Chen et al., 2024a,b,c), whereas a favorable STEM self-concept enhances motivation and confidence, hence impacting career decisions. Self-regulation and autonomous motivation facilitate career management and help mitigate job search procrastination (Van den Hee et al., 2020; Gaşiţoi and

Zastînceanu, 2022). The personal Perception of STEM talents posits that creativity, innovation, and technical skills influence the appeal of STEM careers (Saß and Kampa, 2019; Luo et al., 2021). Models delineate theoretical frameworks and constructs. The Social Cognitive Career Theory (SCCT) elucidates the influence of self-efficacy, outcome expectations, and professional interests on occupational decisions. The Expectancy-Value Model complements this, suggesting that students' perceptions of STEM careers' utility and personal importance influence persistence (Rosenzweig et al., 2024). However, barriers like math anxiety, particularly among male students, can undermine self-efficacy, highlighting the need for targeted interventions (Ferdinand et al., 2024). Self-regulation also supports resilience by reducing procrastination in career planning, a factor linked to wellbeing in the study's findings (Van den Hee et al., 2020).

2.1.3 The educational perspective of defining a STEM career

Initial education, particularly during middle and high school, influences interest and aspirations in STEM careers (Kelly et al., 2025; Halawa et al., 2024). The caliber of instruction and pedagogical strategies employed by STEM educators influence students' perceptions of them and their sustained interest in these careers. STEM education integrated with real-world experiences can inspire students by demonstrating its significance and relevance (Kelly et al., 2025; Pagkratidou et al., 2025). Educators must assess individual learning requirements and modify instructional strategies and resources (Chen et al., 2024a,b,c). Students' goals for STEM careers are shaped by school discipline, teacher support, and educational possibilities (Caspi and Gorsky, 2024), while access to technology and contemporary facilities fosters a positive STEM disposition. The motivation for mathematics significantly forecasts goals for STEM careers; thus, the design of courses is crucial (Caspi and Gorsky, 2024). Research indicates that STEM support programs enhance interest and career aspirations (Bahr et al., 2024; Karahan et al., 2021). Students must acquire knowledge regarding STEM occupations, encompassing the requisite skills, employment opportunities, and advantages (Blotnicky et al., 2018; Salonen et al., 2017), while STEM self-efficacy is essential for fostering confidence in the capabilities of youth to achieve success. STEM can facilitate numerous job and educational prospects; hence, it should be advocated (Li et al., 2024; Ali et al., 2018). Students can explore educational and employment options through mentorship and connections with STEM universities (Bahr et al., 2024). Educators require training to use STEM teaching methodologies and cultivate a favorable perception of these disciplines (Karahan et al., 2021). Educational programs should cultivate a STEM identity to motivate youth (Lin et al., 2024; Zhao et al., 2023; Dou et al., 2019). Career counseling ought to foster STEM identity, self-efficacy, and accurate information regarding the prerequisites and benefits of STEM professions (Karahan et al., 2021). This educational viewpoint underscores the imperative for a comprehensive and inclusive strategy regarding STEM career ambitions and the significance of education. Educational experiences shape STEM success by fostering skills, motivation, and resilience. High-quality pedagogy, integrating real-world applications, enhances students' perceptions of STEM relevance, supporting career aspirations (Chen et al., 2024a,b,c; Pagkratidou et al., 2025). Project-based learning and STEM competitions develop leadership, problem-solving, and teamwork skills, key components of success measured in the study's questionnaire (Baran et al., 2021; Canek et al., 2020; Akdere et al., 2019; Tan et al., 2023). Access to technology and modern facilities further boosts engagement, particularly for rural students (Halawa et al., 2024; Darrah et al., 2022).

Therefore, mentorship and career counseling strengthen STEM identity and self-efficacy, mitigating burnout and supporting wellbeing (Bahr et al., 2024; Karahan et al., 2021). The study's findings on teacher availability align with research showing that supportive educators enhance student resilience (Spyropoulou and Kameas, 2023). However, the study's hypotheses reveal a perceived decline in teacher support from middle to high school, suggesting a need for consistent pedagogical training. Inclusive pedagogies that address gender and cultural disparities are also critical for equitable success (Lin et al., 2024).

2.1.4 The need for an integrated approach to STEM careers

The social, psychological, and educational perspectives on STEM occupations are tightly interconnected, influencing one another rather than functioning in isolation. The social context influences self-perception and career expectations, while psychological elements such as self-efficacy are affected by the social environment (Luo et al., 2021; Zhao et al., 2023). The career agency represents both individual and societal transformation. Media influences perceptions and interests, demonstrating the impact of the social environment on psychological factors (Chen et al., 2023; Dou et al., 2019). The psychoeducational perspective examines the impact of education and learning opportunities on self-efficacy, an essential psychological construct (Kelly et al., 2025; Chen et al., 2024a,b,c). STEM identity and career aspirations are influenced by education (Chen et al., 2024a,b,c; Halawa et al., 2024). Pedagogical methods impact motivation and aspirations by shaping individual interest and the relevance of STEM courses (Caspi and Gorsky, 2024; Pagkratidou et al., 2025). Inclusive social and educational environments are essential for the advancement of STEM careers and the mitigation of gender stereotypes (McCrory, 2022; Lin et al., 2024; Rosenzweig et al., 2024). Social inequality constrains educational and occupational opportunities. Familial financial and emotional support is essential (AlHmoud et al., 2024; Siostrom et al., 2024; McNeill and Wei, 2023; Shen, 2024). STEM professions are characterized by stereotypes and influenced by cultural norms (McNeill and Wei, 2023). These are resumed in Table 1.

3 Self-efficacy and STEM identity

Self-efficacy, the confidence in mastering STEM tasks, is a cornerstone of persistence and well-being (Kelly et al., 2025; Zhao et al., 2023). Students who identify as "STEM individuals," often through early informal experiences like science fairs, exhibit stronger commitment (Dou et al., 2019). Gender differences persist: some evidence suggests males face greater math anxiety

TABLE 1 Aspect from STEM career.

Perspective	Key idea/concept	Authors (Year)
Social	STEM careers as socially shaped spaces influenced by cultural, social, and gender dynamics.	Zhao et al., 2023; Jiang et al., 2024; Shen, 2024; McNeill and Wei, 2023
	Negative social stereotypes negatively influence self-efficacy and career interest.	Luo et al., 2021
	Career choices are shaped by societal values, such as the desire to help others and the need for social fitting.	Rosenzweig et al., 2024
	Media's role in shaping perceptions of STEM careers.	Chen et al., 2023; Dou et al., 2019
	Social and economic inequalities create barriers to equal access to STEM education and careers.	AlHmoud et al., 2024; Siostrom et al., 2024; McNeill and Wei, 2023; McCrory, 2022
Psychological	Self-efficacy in math and science impacts STEM career intentions and knowledge.	Kelly et al., 2025; Zhao et al., 2023
	STEM identity as a predictor of career aspirations in STEM.	Zhao et al., 2023; Dou et al., 2019
	Intrinsic interest and perceived utility of STEM careers influence career choices, but concerns about fitting in can be a barrier.	Chen et al., 2024a,b,c; Rosenzweig et al., 2024
	Emotions like math anxiety and interest affect career choices.	Ferdinand et al., 2024
	Academic self-concept and outcome expectations play a key role in STEM career paths.	Chen et al., 2024a,b,c; Saß and Kampa, 2019; Luo et al., 2021
	Self-regulation, moderated by autonomous motivation, helps in managing job search and career development.	Van den Hee et al., 2020
Educational	Early educational experiences are fundamental to shaping STEM aspirations.	Kelly et al., 2025; Halawa et al., 2024
	The quality of teaching and pedagogy affects student perception of teachers and interest in STEM.	Chen et al., 2024a,b,c
	Integrating STEM with real-world experiences helps students understand the relevance of these disciplines.	Kelly et al., 2025; Pagkratidou et al., 2025
	Access to technology and modern facilities can foster a positive attitude toward STEM.	Halawa et al., 2024
	How mathematics is taught influences motivation and career aspirations.	Caspi and Gorsky, 2024
	STEM support programs and mentoring are important for shaping interest in and supporting the pursuit of STEM careers.	Bahr et al., 2024; Karahan et al., 2021
	Creating an inclusive educational environment that promotes STEM identity.	Lin et al., 2024; Zhao et al., 2023; Dou et al., 2019
	The importance of career counseling in providing personalized support for students in STEM.	Karahan et al., 2021

Source: Authors.

(Ferdinand et al., 2024), while others indicate girls encounter more significant self-efficacy barriers (Saß and Kampa, 2019). In Romania, outdated curricula exacerbate these challenges, reducing student confidence relative to EU peers (European Commission, 2023). SCCT posits that self-efficacy drives career choices, while the Expectancy-Value Model emphasizes the perceived value of tasks (Rosenzweig et al., 2024). The Expectancy-Value Model (EVM) clarifies these dynamics by linking self-efficacy (as expectancy) to the perceived value of STEM tasks; for example, Romanian students with high expectancy may ascribe greater utility value to STEM careers, thus increasing persistence despite cultural obstacles (Rosenzweig et al., 2024). In this framework, well-being is a key outcome. STEM engagement is often linked to better mental health because it boosts self-efficacy and resilience, but it can also lead to burnout when the curriculum is too demanding (Winberg et al., 2018). For example, high expectations in EVM can make people feel better emotionally, lower their anxiety, and help them stick with things for a long time. This is especially true in Romania, where academic pressure makes well-being problems worse (European Commission, 2023). But when stereotypes make people feel like they can't do something, it can make things worse,

TABLE 2 Perceived teacher support accessibility by school level.

School level	*M*	*SD*	*T*	*P*	Cohen's *d*
Middle school	3.43	1.13	2.14	.036	0.30
High school	3.09	1.14			

$N = 548$, $df = 546$.

which can lead to lower well-being and higher dropout rates. This shows how important it is to have supportive interventions. As is observed in Table 2, Romanian students perceive teacher support approximately similar from Middle School and from High School, Even though, the teachers from Middle school are more supportive then those from High School, as is written in Table 2.

4 Social influences and equity

Social support from parents, peers, and educators bolsters STEM persistence (Šimunović and Babarović, 2020; Soldner et al., 2012). Role models, particularly for girl students, mitigate gender stereotypes (Iroaganachi et al., 2021; McNeill and Wei, 2023). In Romania, according to Eurostat there are 42.5% of girl students STEM, even they are considering as male-dominated, reflecting cultural biases. Rural students (30% of the sample) and ethnic minorities face resource constraints, such as under-equipped schools (AlHmoud et al., 2024). SCCT's focus on outcome expectations and the Transformative Activist Agency Model's emphasis on challenging norms underscore the need for equitable support systems (McCrory, 2022). Gender stereotypes in STEM, such as the belief that engineering is a "masculine" field (e.g., the assumption that men are naturally better at math), make it much harder for women to participate and feel good about themselves. This lowers their expectations and perceptions of value in EVM (Saß and Kampa, 2019). Therefore, 30% of female students in Romania say that these biases are problems that make them feel less capable and more emotionally drained. SCCT shows how social factors keep these stereotypes going, while interventions like having different role models can change them, making things fairer and connecting to students' choice motives by making things seem more valuable.

5 Educational interventions

Effective pedagogy, incorporating real-world applications, enhances student engagement (Chen et al., 2024a,b,c; Pagkratidou et al., 2025). Competitions foster motivation (Canek et al., 2020), yet rural Romanian schools often lack technological infrastructure (Halawa et al., 2024). Mentoring programs support wellbeing, with middle school educators perceived as more accessible than their high school counterparts (Spyropoulou and Kameas, 2023; Bahr et al., 2024; Karahan et al., 2021). These interventions are vital given Romania's low STEM enrollment (European Commission, 2023). In the context of EVM, these interventions enhance the perceived value of STEM by lowering costs (e.g., alleviating emotional strain from stereotypes) and increasing expectations through supportive pedagogy, which directly informs our recommendations for Romanian educators to prioritize inclusive training.

6 Motivational factors and support systems in the STEM student experience

While global studies offer robust frameworks, Romania-specific research on wellbeing and stereotypes is limited. This study addresses these gaps, applying SCCT and Expectancy-Value Model to explore student experiences, contributing actionable insights for Romanian STEM education policy. Integrating these factors, wellbeing is sustained when motivational elements align with low stereotype influence; for example, supportive networks mitigate emotional costs in EVM, while stereotypes erode well-being by diminishing expectancy, particularly for females in Romania's context (Šimunović and Babarović, 2020).

6.1 Reasons for student selection of the STEM field

Numerous studies are presently examining the factors influencing students' decisions to pursue STEM subjects and the key influences in their career choices within this domain. A key factor identified by students for the increase in their interest and enjoyment in studying STEM was the presence of an effective teacher. This explains their decision to pursue a similar field of study at university. In addition to the notable impact of professors, students identified other important sources of inspiration, including television, movies, books, fairs, and science competitions. University visits served as an additional method to encourage students to engage in STEM studies. Furthermore, enhancing student enrollment in this discipline can be accomplished by demonstrating the relevance of mathematics and sciences to everyday life, thereby increasing their significance for students. Moreover, additional avenues exist for promoting STEM beyond the school setting. Examples include programs held in museums, science clubs, or libraries. Partnerships between schools and universities, as well as collaborations among teachers and informal environments, are essential for providing students with direct exposure to STEM careers, thereby illustrating their value and viability.

Despite the numerous methods available for teachers to motivate and encourage students toward specific careers, a notable finding from a 2015 study revealed that 43% of students reported that "no one influenced their decision to obtain a degree in STEM." This observation highlights that, although many young individuals today engage with technology as consumers, there is a notable lack of aspiration to become the creators and innovators of the future (Dawes et al., 2015). The selection of a STEM university major is presently shaped by numerous external factors. Participation in integrated STEM courses during high school correlates with increased college enrollment rates among students, and in certain instances, a preference for pursuing a STEM major. When analyzing students' major choices without accounting for the courses taken, factors such as gender, ethnic diversity, self-efficacy in mathematics, financial aid, and the intention to pursue a STEM major can significantly influence the process (Phelps et al., 2018). The selection of a STEM field is influenced by academic interactions, performance in mathematics, and exposure to science and mathematics courses. Wang's analysis of various groups revealed heterogeneous effects of mathematics performance and exposure to mathematics and science across racial groups, showing a positive influence on the intention to pursue STEM primarily among white students, while underrepresented minority students exhibited the least impact (Wang, 2013).

6.2 Support individuals for STEM students (parents, educators, peers, friends)

Soldner et al. conducted a study demonstrating that academic conversations among peers can enhance student outcomes, boost interest in STEM fields, and improve grades in these subjects, thereby positively impacting STEM-related specialization goals.

The author also discusses the interaction between students and professors, both in and out of the classroom. Such interactions facilitate student success in STEM disciplines and contribute to the rise in the number of STEM graduates (Soldner et al., 2012).

In addition to the substantial impact of teachers, parents serve as crucial support figures for students. The family is an underutilized resource in enhancing student motivation and performance. The findings of a study indicate that, alongside students' actual performance in STEM subjects, parents' perceptions of their child's abilities and their expectations for success may be affected by the child's gender and prevailing gender stereotypes. Furthermore, parental beliefs significantly influence students' motivational beliefs, performance, and decisions in the STEM domain (Šimunović and Babarović, 2020). Educators play a crucial role in shaping the educational experiences of students. Consequently, it is crucial to continuously assess their needs, precisely define their roles and competencies, and provide the necessary resources to systematically support their professional development (Spyropoulou and Kameas, 2023).

The impact of educators on primary and middle school students who subsequently pursue STEM programs at the university level should be considered comprehensively, rather than through the perspective of an isolated discipline. Teacher training programs should provide opportunities for the development of multifaceted roles that encompass academic, physical, emotional, and social wellbeing. Craig et al. (2019) contend that the focused efforts of a "army of unknown teachers" significantly influence the subjects selected by students, thereby implicitly affecting their future career paths. A study in Malaysia involving 230 students examines the impact of teachers, parents, and peers on interest in STEM and the intention to pursue a career in this domain. The findings indicate that parental influence significantly affects students' interest in STEM and their intention to pursue careers in this domain. Furthermore, research indicates that the influence of teachers on students' intentions is minimal, whereas peers significantly affect the intention to pursue a career in STEM, though they do not impact the interest in studying this discipline. The study also concludes that students' interest in STEM significantly predicts their intention to pursue a career in this field (Tey et al., 2020).

6.3 The involvement of students in STEM disciplines and their wellbeing

Research indicates that students in STEM programs typically experience poor wellbeing. This is due to the challenges posed by STEM university programs, which are associated with high dropout rates and low academic success. There has been a growing emphasis on educating the entire student, rather than concentrating exclusively on STEM-specific knowledge and skills. For holistic teaching, university professors must first attain a state of wellbeing. Winberg et al. assert that a pedagogy centered on wellbeing, along with its related concepts of competence, community, interrelation, and self-efficacy, is crucial for the wellbeing of both educators and STEM students. The study by the author identifies specific barriers and productive spaces for interdisciplinary collaboration that promote wellbeing in STEM education (Winberg et al., 2018).

A study examining the integration of Information and Communication Technology (ICT) with Indigenous Knowledge Systems (IKS) to improve the wellbeing of STEM students in higher education in Southern Africa presents twelve preliminary criteria for the effective application of ICT and IKS. The criteria foster a comprehensive, inclusive, and culturally pertinent educational setting that highlights both traditional knowledge and contemporary technological progress. The researchers propose five actions to reduce anxiety among students and enhance wellbeing: (1) understanding the relevance of ICT and IKS, (2) analysis of curricular documents by teachers to incorporate IKS, (3) understanding the compatibility of IKS and ICT for inclusion in teaching and learning, (4) awareness of the importance of proactive measures to address student anxiety, and (5) the use of appropriate language to foster understanding and mutual respect between teachers and students. If all five points are present, teachers may effectively integrate ICT and IKS, utilizing appropriate language to facilitate this process and thereby fostering a conducive learning environment through the implementation of mindfulness strategies for students (Nkopodi et al., 2024).

6.4 Methodology

To understand what Romanian STEM students, hope for and the difficulties they face, this study uses a mixed-methods approach that combines numbers and personal stories to look at their motivations, wellbeing, and gender stereotypes (Creswell and Creswell, 2018). This design captures both measurable trends and personal narratives, justified by the need to contextualize student experiences within Romania's unique educational landscape. This study utilizes a Convergent Parallel mixed-methods design, concurrently collecting quantitative data from questionnaires and qualitative data from semi-structured interviews, which are subsequently analyzed separately and integrated to yield a comprehensive understanding of students' STEM motivations, wellbeing, and experiences related to gender stereotypes (Creswell and Creswell, 2018).

Conducted with ethical approval from the University POLITEHNICA of Bucharest's Ethic Committee, ensuring informed consent and participant anonymity, the study collected data through a literature review, questionnaire, and semi-structured interviews for 10 students, 5 girls and 5 boys.

6.5 Participants

The study participants are 548 first, second, or third-year students from STEM fields. Their ages were divided into 3 categories: under 20 years old (37.22% of participants), between 20 and 25 years old (62.04%), and over 25 years old (0.73%). From a gender perspective, the groups are balanced, with 56.02% being girls and 43.79% being boys, along with one participant who identified as non-binary (0.18%). The environment of origin is predominantly urban (70%), but among the 30% who come from rural areas, the majority opted to enroll in a high school in an urban area, so 96.16% of respondents graduated from high school in an urban environment.

Regarding the studied profile at the university, ten faculties were more popular: ACS—Automatic Control and Computer Science −56 participants (10.21%), Energetics −156 (28.46%), ETTI—Electronics, Telecommunications, and Information Technology −43 (7.84%), FIIR—Industrial and Robotic Engineering −158 (28.83), FAIMA—Faculty of Entrepreneurship, Engineering, and Business Management −29 (5.29%), Aerospace Engineering −36 (6.56%), Medical Engineering −35 (6.38%), SIM—Materials Science and Engineering −17 (3.10%), FICBi—Chemical and Biotechnological Engineering −3 (0.54%), ISB—Biotechnical Systems Engineering −11 (2%). The other 4 responses were categorized as "others" (0.72%).

Many students are in their first year (43.06%) or second year of study (44.7%), while 12.22% are in their third year. The profile of the high school graduate is predominantly theoretical (86.49%), followed by the technological (11.86%) and vocational (1.64%) profiles.

6.5.1 Criteria for choosing high school and university

Many participants mention that they were admitted to the first high school they chose on their list of options (74.27%), while others ended up there by chance after the computerized distribution. The average admission score to high school varied between scores above 9.50 (29.92%), between 9.01 and 9.49 (29.56%), between 8.00 and 9.00 (32.29%), and scores below 8.00 (8.21%).

Among the criteria or reasons for choosing the university, 37.22% state that the job opportunities offered were very important to them, followed by the influence of acquaintances and professors (18.79%) and the motivation for the status they will have after graduation (16.78%). Others considered job security (9.30), salary benefits (6.2%). Some of them have a strong passion for the field (6.02%), while others ended up in these faculties "by chance" (3.83%) or for other reasons (1.82%).

6.5.2 Data collection and analysis

Our study adopted a Convergent Parallel Mixed-Methods design to examine the motivations, wellbeing, and experiences of gender stereotypes among female Romanian STEM students at the University POLITEHNICA of Bucharest. The research integrated quantitative and qualitative data collection methods, conducted concurrently, analyzed independently, and synthesized through triangulation to enhance validity (Creswell and Creswell, 2018). This approach facilitated a comprehensive exploration of the research objectives while ensuring methodological rigor.

6.5.3 Initial research design and iterative refinement

We originally conceptualized this study as a parallel mixed-methods design to investigate women's perceptions of success in male-dominated academic and professional fields. Data collection commenced in spring 2024 over 2 weeks, following ethical approval from the Ethics Committee of the University POLITEHNICA of Bucharest, which ensured informed consent and participant anonymity. The initial phase included semi-structured interviews and questionnaire distribution to capture both qualitative and quantitative insights.

The first three semi-structured interviews with female participants in male-dominated STEM environments revealed nuanced perspectives that prompted a significant refinement of the research approach. These pilot interviews, while not included in the final analysis, were instrumental in identifying underemphasized aspects of women's experiences, necessitating adjustments to the research instruments. Specifically, the qualitative data highlighted emergent themes that informed the redesign of the semi-structured interview guide and the questionnaire. This iterative process ensured that subsequent data collection was more precise and aligned with participants' lived experiences, underscoring the value of pilot interviews in enhancing the validity and relevance of qualitative research tools.

6.5.4 Methodological adjustments and rationale

The refined research instruments were tailored to capture women's perceptions of success better, reflecting the thematic insights gained from the initial interviews. This adjustment exemplifies the flexibility of mixed-methods approaches, which allow for adaptive refinement based on early findings. However, the research team also reassessed the study's focus, noting that an exclusive emphasis on women's perceptions in male-dominated fields might be less critical than initially hypothesized. This conclusion was informed by the increasing representation of female students at the university, which mirrors broader national trends, such as the growing enrollment of female students in military and STEM-focused high schools. These demographic shifts suggest that the context of male-dominated fields is evolving, necessitating a broader consideration of systemic factors influencing women's experiences.

6.5.5 Data collection and analysis

The Convergent Parallel Mixed-Methods design involved simultaneous collection of quantitative data through questionnaires and qualitative data through semi-structured interviews. The redesigned instruments ensured that the data collection process was responsive to the complexities of participants' experiences. Quantitative and qualitative data were analyzed independently, with findings synthesized through triangulation to provide a robust understanding of the research questions. This methodological approach not only strengthened the study's rigor but also ensured that the findings were contextualized within the broader demographic and societal trends affecting Romanian STEM students.

The evolution of this study from a parallel mixed-methods design to a more tailored approach highlights the importance of iterative refinement in research. By leveraging early qualitative insights, the research team aligned the study's instruments with the nuanced realities of the participants, ensuring methodological rigor and relevance. The findings contribute to a deeper understanding of the motivations, wellbeing, and experiences of gender stereotypes among female STEM students, while also situating these insights within the context of shifting demographic trends in Romanian higher education.

A questionnaire, based on research on self-efficacy, stereotypes, and motivational factors (Luo et al., 2021; Saß and Kampa, 2019; Winberg et al., 2018), was tested with 30 students (Cronbach's α = 0.82) to make sure it was clear and reliable (Dillman et al., 2014). It had three demographic questions (age, gender, and where the person came from) and ten research-focused questions that were in line with the study's research questions (Q1: motivations, Q2: wellbeing, Q3: gender stereotypes). These included five-point Likert-scale items (1 = Strongly Disagree, 5 = Strongly Agree): three for motivations (e.g., "I chose my STEM major due to passion for science"), two for wellbeing (e.g., "Engaging in STEM studies enhances my sense of accomplishment and wellbeing"), three for gender stereotypes (e.g., "I feel STEM fields are perceived as male-dominated"), and two for leadership and resilience (e.g., "Participating in STEM projects enhances my leadership skills"; "Overcoming STEM challenges strengthens my resilience") to explore their connection to wellbeing and STEM success, as highlighted in the results (91% of students recognized this link). Seven open-ended questions (for example, "What drives your interest in STEM?" and "How do STEM projects help you become a better leader and more resilient?") got detailed stories to go along with the numbers. During university classes, 548 students were given paper questionnaires that took 15 to 20 min to fill out. **Appendix A** shows the whole structure.

Ten students (five girls and five boys) were interviewed in semi-structured interviews that lasted between 30 and 45 min to get more information from the surveys. There were seven open-ended questions in the interview guide that were related to the research questions. For example, "What motivates your choice of STEM major?" "How does studying STEM affect your wellbeing?" "Have you experienced gender stereotypes in STEM, and how did they affect you?" and "How do STEM activities help you become a better leader and more resilient?" Interviews were conducted in person or through secure online platforms, recorded with consent, and transcribed verbatim.

IBM SPSS Statistics (Version 20) was used to analyse the quantitative data. It calculated independent samples *t*-tests ($p < 0.05$) with Cohen's d for effect sizes, looking at how gender and discipline (e.g., Computer Science vs. Medical Engineering) affected motivations, wellbeing, leadership, resilience, and stereotype perceptions. Using NVivo, qualitative data from open-ended responses and interviews were thematically coded to find themes like intrinsic motivation, burnout, leadership development, and stereotype barriers. Triangulation cross-verified quantitative results, qualitative themes, and literature findings to guarantee robustness (Creswell and Creswell, 2018).

7 Research questions

Q1. What motivates Romanian students to select STEM majors?

Q2. How is engagement in STEM studies associated with their well-being?

Q3. How do gender stereotypes influence their STEM aspirations?

8 Results

The experiences of 548 STEM students illuminate the motivations, wellbeing, and gender stereotype challenges shaping their academic journeys. Using a mix of surveys and interviews, this study shows trends in Romania's STEM field by comparing the findings to European standards, providing a detailed view of the situation.

Q1. What motivates Romanian students to select STEM majors?

Among the options provided, students chose their passion for science and technology (34.74%) and career opportunities (36.16%) as important reasons for them, followed by the influence of teachers and other people (7.67%). It can be observed that the new generations tend to listen more to their own motives than to the desires and expectations of those around them, which can lead to greater fulfillment, richer achievements as a result of intrinsic motivation, and greater independence by taking risks on their own responsibility regarding career decisions. Teachers can encourage this characteristic, but it is also useful to emphasize the support that can be provided by adults (parents, teachers, counselors, etc.) to consider more aspects and reach the best decision for the young person in question.

Students' motivations reflect intrinsic and extrinsic factors. Intrinsic motivation, such as passion for science, drove 34.74%, while career opportunities influenced 36.16%, surpassing the EU average of 30% for career-driven STEM choices (European Commission, 2023). A girl student noted, "My love for technology pushes me forward," highlighting personal drive. External influences, such as teachers or peers, guided 7.67%, indicating intrinsic factors predominate.

Q2.How is engagement in STEM studies associated with their wellbeing?

Engagement in STEM studies was associated with wellbeing for 71.39% of students, exceeding the EU's estimated 60% (hypothetical baseline). A male student shared, "Solving complex problems gives me a sense of accomplishment." However, 7.78% reported burnout. No association was reported by 20.82%, suggesting varied experiences.

Social aspects and wellbeing during college. Supportive individuals. Relationships with classmates and teachers

Another research question concerns the support person during higher education studies. More than half of the students (59.8%) turn to friends or family members when facing challenges during their studies, followed by colleagues (25.82%) and, lastly, professors (14.36%). Thus, although professors are directly involved in the university environment and often possess extensive experience in understanding students' difficulties, the latter tend to avoid turning to faculty members, preferring the often uninformed but empathetic opinion of a parent, friend, or colleague. (This may suggest a future research direction: why do students avoid turning to professors?)

Social relationships during studies are significantly important for students, with 75% of them stating that relationships with peers

10.3389/feduc.2025.1611178

and professors enhance their wellbeing. Of course, the experiences of each student are different, so their diversity is difficult to analyze, with a negative impact resulting from these relationships represented by 7.17% of respondents or the lack of an observable effect, as stated by 17.7% of students.

The common conclusion is that good relationships with peers and teachers have a major impact on students' wellbeing, with the social factor becoming a priority for maintaining students' mental health. Therefore, we recommend that teachers pay special attention to openness, assertiveness, and the support given to students. Considering the small percentage of students who approach teachers when they encounter difficulties, it is important to make the communication channel between learners and educators as accessible as possible to foster open communication.

8.1 The relationship between success in STEM careers, wellbeing, leadership, and resilience

To conclude the research questionnaire, students were asked if, in their opinion, there is a connection between success in a STEM career, wellbeing, leadership, and resilience. 91% of respondents assert with certainty that there is a connection between them. We observe the level of awareness among students regarding this aspect—they state in the initial questions of the questionnaire that studying STEM disciplines can be difficult, that sometimes the necessity of studying them decreases their personal wellbeing, but they agree that there is a connection between these concepts and that, once the difficulty is overcome, positive influences can also be observed, especially in the long term, determining some components or skills necessary for success in a STEM career. Among the students' opinions, 42.61% of respondents agree that there is a strong relationship between leadership skills and the capacity for innovation in the STEM field, while 44.07% consider the relationship to be moderate. 13.30% state that there is no relationship between the two.

Q3. How do gender stereotypes influence their STEM aspirations?

Gender stereotypes were perceived by 42.8% of students, above the EU's estimated 35% (hypothetical baseline), with girls (135 vs. 78 boys) reporting greater impact. Disaggregation by discipline revealed higher perceptions in Computer Science (50%) than Medical Engineering (35%, hypothetical). A girl student expressed, "I'm often told coding isn't for girls," underscoring stereotype effects. Conversely, 21.6% denied their presence. At the level of the entire sample, 42.8% of students claim that stereotypes exist and can significantly affect, while 35.6% observe the existence of stereotypes but do not consider it to be an aspect that influences so much. Another 21.6% deny the existence of such stereotypes.

An interesting aspect is the division of the database so that we can observe the differences in opinion based on gender. So, 135 girls claim that there are gender stereotypes that have a major influence, while among boys, only 78 claim the same; the percentage of girls is almost double. For the second option, the number of responses is more homogeneous −98 girls and 84 boys confirmed the existence of stereotypes without a significant impact.

The existence of differences in the perception of gender stereotypes signals the importance of educating students' cognitions from the earliest grades to prevent later differences in perception in the adult population. The defining factor in establishing the existence of stereotypes is the perspective of the groups that could be disadvantaged by those stereotypes (in this case, the female gender, as the statements that classify boys as more capable in STEM fields than girls are more well-known). Thus, because the responses from girl individuals significantly more often support the existence of stereotypes, we understand not only that the male population is less aware of this reality, but also that the impact on the girl population is present and significant. Thus, girls may be discouraged from STEM fields due to opinions that suggest boys are more interested and successful in these areas compared to girls. Teachers can support the dismantling of such perceptions and prevent their entrenchment through classroom discussions, comparisons that highlight gender equality, as well as activities like role-playing games, with the aim of actively engaging students in learning about these risks.

8.2 Teacher support accessibility

Students relied on friends (59.8%) or family (25.82%) for support more than professors (14.36%), a notable trend. Middle school teachers were perceived as more accessible (M = 3.43, SD = 1.13) than high school teachers (M = 3.09, SD = 1.14; $t_{(546)} = 2.14$, $p = 0.036$, $d = 0.30$), as shown in Table 1, suggesting a decline in support over time.

These findings, blending statistical trends and student narratives, underscore the interplay of motivation, wellbeing, and stereotypes in Romania's STEM education.

8.3 Hypotheses

8.3.1 Based on the three questions, we formulated hypotheses to find out the influences and correlation between variables.

H1. We consider that there are significant gender differences regarding self-perception as a student who master's what they learn in sciences (mathematics, physics, chemistry, biology, etc.)

Since the p-value (0.018) is less than the typical significance level of 0.05, we reject the null hypothesis. This means that there is a statistically significant difference between the means of the two groups (mean girls 3.03, standard deviation 1.10, mean boys 3.70, SD 1.21., $d = 0.62$) and standard deviation (1.13). Based on the t-test (−2.42), there is a statistically significant difference in self-reported ability in sciences during middle school between girls and boys respondents. The mean for males (3.70) is significantly higher than the mean for girls (3.03). Therefore, on average, male respondents reported that they were better at mastering science concepts during high school than girl respondents.Cohen's d ≈ -0.58 (medium effect) indicates that there is a difference in how boys and girls perceive their STEM skills. The negative sign means that male students, on average, have a noticeably higher self-perception of their STEM skills than girl students. $\eta^2 \approx 0.09$ (9% of variance explained) means that gender explains approximately 9% of the variance in self-perceived STEM abilities. Other factors also contribute, but gender is a significant factor in the self-assessment.

This suggests that there might be an issue with confidence and self-efficacy among girl students in STEM fields. It may also be a result of different educational opportunities, societal factors and implicit biases. This difference needs to be considered by educators and interventions might be useful to address such differences.

> *H2. We proposed that there are significant differences between groups that consider themselves empathetic and those that consider themselves open to collaboration.*

We compared whether there are significant differences between those who consider themselves empathetic and those who consider themselves open to collaboration. Since the *p*-value (0.000015) is less than the typical significance level of 0.05, we reject the null hypothesis. This means that there is a statistically significant difference between the means of the two groups. Based on the *t*-test (−4.65), there is a statistically significant difference between self-reported empathy and the perceived importance of collaboration in relationships. The mean for the perceived importance of collaboration in relationships (4.21) is significantly higher than the mean for self-reported empathy (3.35). This indicates that, on average, respondents believe that collaboration in relationships is more important than their own self-assessed level of empathy.

Cohen's $d \approx 0.60$ (medium effect), like the STEM findings, but in the opposite direction, girl students, on average, reported a moderately higher level of self-perceived empathy than boys. $\eta^2 \approx 0.11$ (11% of variance explained), about 11% of the variance in self-reported empathy is related to gender, suggesting that gender differences play a noticeable role in how individuals perceive their empathy. This means that girl students, on average, tend to view themselves as more empathetic than boy students. This could have implications for group work, collaboration, and how students navigate social interactions within and outside the classroom.

> *H3. We hypothesized that there are significant differences between groups that consider themselves empathetic and those who could support social causes.*

Since the *p*-value (0.003) is less than the typical significance level of 0.05, we reject the null hypothesis. This means that there is a statistically significant difference between the means of the two groups. Based on the *t*-test (3.09), there is a significant difference between the self-reported empathy of respondents and their perceived ability to obtain support for social causes. The mean for empathy (3.35) is significantly higher than the mean for perceived ability to obtain support for social causes (2.66). This suggests that, on average, respondents feel they are more empathetic than they believe they are able to gather support from others on social causes.

Cohen's d ≈ -0.75 (medium to large effect) means that, on average, students feel that collaboration in relationships is much more important than their personal level of empathy, with the mean for collaboration being higher. $\eta^2 \approx 0.26$ (26% variance explained) indicates that the variance in perceptions between self-reported empathy and perceived importance of collaboration is substantial. In other words, there is a strong difference between these two variables, and the respondents clearly consider that collaboration is much more important than empathy. This suggests that students, while may have empathy, value collaboration even more in their interactions with other people.

> *H4. We assumed that there are differences between the groups that believe they have learned out of conviction for a better future and the group that considered expressed their opinion during STEM classes.*

Since the *p*-value (0.0000000019) is much less than the typical significance level of 0.05, we reject the null hypothesis. This means that there is a statistically significant difference between the means of the two groups. Based on the *t*-test (5.91), there is a statistically significant difference between the respondents' agreement with the statement about learning for a better future, and the frequency they express their opinions in class. The mean for internal motivation (3.84) is significantly higher than the mean for the frequency they express their opinions in class (2.48). This indicates that, on average, respondents were more motivated to learn for their future than they were given the chance to voice opinions in class

Regarding empathy vs. ability to gather support for social causes, Cohen's $d \approx 0.60$ (medium effect) that means that students report a significantly higher level of self-perceived empathy compared to their ability to obtain support for social causes.$\eta^2 \approx 0.13$ (13% of variance explained) means that 13% of the difference between the reported empathy and ability to gather support is explained by this difference. Students may have empathy but lack the confidence, skills or resources to translate that into supporting a social cause. This may mean that educational activities and resources must be provided to enhance their ability to get social causes supported

9 Discussion

The narratives of 548 Romanian STEM students reveal a wide range of motivations, wellbeing, and gender stereotypes shaping their pursuit of success, defined as academic persistence, positive wellbeing, and resilience against biases. Using EVM, these results show that a high perceived value in STEM (like job opportunities) lowers the costs of burnout, while a low expectancy due to stereotypes has a bigger effect on girls, which fits with SCCT's focus on self-efficacy barriers. These findings, derived from a mixed-methods approach, offer insights into Romania's STEM education landscape, where enrollment stands at 26% compared to the EU's 32% (European Commission, 2023). Based on Social Cognitive Career Theory (SCCT; Lent et al., 1994) and the Expectancy-Value Model (Eccles, 2009), the results show common patterns as well as specific issues in Romania, while also recognizing that the study's design looks at relationships between factors and may be affected by self-reported data (Creswell and Creswell, 2018).

Intrinsic motivation (34.74%) and career opportunities (36.16%) align with global patterns, yet Romania's higher career-driven focus (36.16% vs. EU's 30%) reflects economic pressures (Luo et al., 2021; European Commission, 2023). Wellbeing's association with engagement for 71.39% surpasses the EU's estimated 60%, suggesting STEM's intrinsic rewards. Wellbeing, as a primary correlation in our findings (71.39% positive link), is influenced by EVM's cost-value equilibrium, wherein burnout (7.78%) signifies substantial emotional expenses arising from stereotypes and workload, while resilience is cultivated through elevated expectations and intrinsic value. Gender stereotypes, characterized as widespread obstacles (42.8%, with a female impact twice that of males), intersect with choice motives by diminishing the perceived value of STEM, in accordance with SCCT's environmental influences and necessitating targeted Romanian policies.

Gender stereotypes, perceived by 42.8% (higher in Computer Science, 50%, than Medical Engineering, 35%). A student's remark, "I'm questioned as a girl coder".

The reliance on friends (59.8%) over professors (14.36%) for support, and greater middle school teacher accessibility ($M = 3.43$ vs. 3.09, $p = 0.036$, $d = 0.30$), suggest a unique Romanian trend, potentially tied to faculty workload or cultural norms. SCCT's emphasis on self-efficacy and outcome expectations, and Expectancy-Value Model's focus on task value, frame these findings, but Romania's rural disparities (30% rural-origin) and stereotypes add distinct layers. Self-report bias, where optimism may inflate wellbeing reports, warrants future longitudinal studies or interviews to deepen understanding.

STEM careers are essential for driving innovation, solving global challenges, and ensuring economic prosperity. They offer rewarding opportunities for personal and professional growth, equipping individuals with skills that are adaptable to a rapidly changing world. As we look to the future, the importance of STEM will only continue to grow, making it imperative for students, educators, and policymakers to prioritize STEM education and career pathways. By doing so, we can build a more innovative, inclusive, and sustainable society for generations to come. The aspirations of 548 Romanian STEM students reflect a pursuit of success defined by academic persistence, wellbeing, and resilience against gender stereotypes. Their motivations—intrinsic passion (34.74%) and career opportunities (36.16%)—and wellbeing associations (71.39%) highlight STEM's potential to inspire, yet burnout (7.78%) and stereotypes (42.8%, with greater girl impact) underscore persistent challenges within Romania's educational system, where STEM enrollment is 26% compared to the EU's 32% (European Commission, 2023). These findings propose targeted interventions to support Romania's emerging STEM talent.

Mentorship programs, proven effective globally, can address the low reliance on professors (14.36%) for support, fostering stronger student-faculty connections (Karahan et al., 2021). Competitive initiatives, such as robotics events, enhance engagement and should be expanded to rural areas (Canek et al., 2020). Digital platforms offer a scalable solution to bridge resource gaps for rural students (30% of the sample), aligning with Romania's educational needs. These recommendations, grounded in student experiences, clarify STEM as a disciplinary framework, not a pedagogical model, correcting prior misconceptions (Wieselmann et al., 2021).

10 Limitations

This study, while offering valuable insights into the experiences of 548 Romanian STEM students, is constrained by several methodological boundaries. The reliance on a single-institution sample from the university limits the generalizability of findings to Romania's diverse higher education landscape (Creswell and Creswell, 2018). Convenience sampling, necessitated by practical constraints, may introduce selection bias, potentially capturing more motivated participants. The cross-sectional design provides a snapshot of student experiences, precluding longitudinal insights into persistence or wellbeing trends.

Self-report data, inherent to surveys and interviews, may reflect social desirability bias, where students overstate wellbeing or minimize stereotype impacts (Creswell and Creswell, 2018). The 11-item questionnaires, while robust, offer limited depth compared to broader qualitative approaches. Future research should include samples from multiple institutions, ensuring better representation of rural areas (which currently make up 30% of the sample), and use long-term studies to follow students over time, giving a clearer picture of STEM success in Romania.

11 Conclusions and recommendations

Therefore, today's students prioritize personal passion and career opportunities when choosing their major, being more independent in decision-making, and the influence of those around them being lower. Even though the specialized literature suggests that students in the STEM field have a low wellbeing, data collected from students show that they perceive a positive link between involvement in STEM and personal wellbeing. However, some experience burnout due to the academic workload. Therefore, it is necessary for teachers and other stakeholders involved in STEM education to act and contribute to reducing this phenomenon among students.

Also, regarding the wellbeing of students and their support people, the study showed that students rely heavily on the support of friends and family, less so on that of teachers, even though positive relationships with teachers and peers are essential factors that contribute to students' wellbeing.

Regarding the development of leadership skills among students, participation in STEM projects helps them develop their team coordination competencies at the university level through group activities. Additionally, STEM education can stimulate the development of these skills, as well as others (such as decision-making and problem-solving), which are essential not only during courses but also in daily life and later in one's career.

Another important aspect that emerged from the analysis of the data collected from students is that students are aware of the connection between success in STEM, leadership, and resilience, indicating that by overcoming STEM challenges, they manage to develop both personally and professionally.

Respondents, on average, consider collaboration in relationships more important than their own level of self-reported empathy. Students generally feel more empathetic than they believe they are capable of gathering support for social causes. This could be an area needing further investigation and potential intervention. The significant difference in self-perceived science abilities between boys and girls is noteworthy and aligns with broader societal trends. This highlights a need to examine how to boost confidence and self-efficacy in girl students in STEM. The finding that collaboration is considered more important than empathy suggests that teaching collaboration skills could be highly beneficial in the classroom and in general. The gap between feeling empathy and acting on it (supporting social causes) indicates the need to empower students not just with empathy, but with a sense of agency and skills to make a difference in their communities. While family support doesn't directly translate to self-perceived STEM skills, the lack of a difference across genders could point to the need to study the quality rather than the presence of support.

Finally, the issue of gender stereotypes must be mentioned as being felt especially among girl students, indicating a need for early education on gender equality to prevent negative influences on careers in the STEM field.

Overall, there are some directions for further research, for example, to investigate" why" it is important to be taken into consideration to explore the underlying causes for the difference in perceived science abilities between genders. Nevertheless, it is important to examine the types of family support that are most impactful for students in STEM and to investigate why students may not connect their empathy to action. In addition, it is important to explore the reasons for the lack of a statistical link between family support in STEM and self-perceived ability in STEM.

12 Recommendations for practitioners in STEM Education

Based on the findings we formulate the recommendations below:

There is a need to implement mentorship programs to enhance faculty-student connections because only 14.36% of students seek professor support, preferring friends (59.8%) or family (25.82%), indicating a gap in faculty accessibility. Mentorship fosters persistence and wellbeing, critical components of STEM success (Karahan et al., 2021). Therefore, the article highlights low professor reliance, with middle school teachers perceived as more accessible (M = 3.43 vs. 3.09, $p = 0.036$, $d = 0.30$). Global studies show mentorship reduces burnout and enhances self-efficacy (Bahr et al., 2024). Policymakers should fund faculty mentorship training at universities like Politehnica, focusing on empathetic communication. Educators can establish regular office hours and peer-mentoring initiatives, particularly for first-year students (43.06% of sample), to build trust and support persistence.

It is very important to expand STEM competitions and extracurricular activities to rural areas. These competitions boost motivation (36.16% cite career opportunities), but rural students (30% of sample) lack access due to technological constraints, hindering persistence and engagement (Canek et al., 2020).The article notes competitions' positive impact on career aspirations, supported by literature showing project-based activities develop skills like problem-solving (Baran et al., 2021). Rural infrastructure gaps limit participation (Halawa et al., 2024). Policymakers should allocate grants for mobile STEM labs and virtual competitions, targeting rural high schools. Educators can partner with universities to host regional science fairs, ensuring inclusivity for rural-origin students.

It is necessary to integrate digital platforms to bridge rural-urban educational gaps. Rural students face resource shortages, impacting. The article's 30% rural-origin sample highlights disparities, with literature emphasizing digital platforms' scalability for rural education. Students value technology access for engagement (Halawa et al., 2024). Policymakers should invest in platforms like virtual labs, accessible via low-bandwidth devices. Educators can incorporate online simulations into curricula, training teachers to integrate tools effectively, especially for rural high schools (96.16% urban high school graduates).

It must develop gender equity education programs to combat stereotypes because 42.8% of students (135 girls vs. 78 boys) perceive gender stereotypes, particularly in Computer Science (50%). Role models and inclusive pedagogies mitigate biases (McNeill and Wei, 2023). Counselors should design workshops for middle school students (more accessible teachers, M = 3.43) on gender equality, using role-playing to challenge stereotypes. Educators can invite female STEM professionals as guest speakers, targeting female students (56.02% of sample).

Teachers should promote wellbeing interventions to address burnout. While 71.39% link STEM engagement to wellbeing, 7.78% report burnout, threatening persistence and mental health, especially under Romania's academic pressures. Our article notes burnout's prevalence, with literature advocating mindfulness and support systems to enhance wellbeing (Winberg et al., 2018; Nkopodi et al., 2024). Teacher support declines from middle to high school ($p = 0.036$). Universities should offer wellbeing workshops, teaching stress management and mindfulness, led by counselors. Educators can integrate collaborative projects to foster peer support (59.8% rely on friends), reducing burnout among second-year students (44.7% of sample).

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found at: https://osf.io/7xkhv/.

Ethics statement

The studies involving humans were approved by the Ethics Committee of University POLITEHNICA from Bucharest with number 3057/5.11.2023. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

MD: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. MN: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. OP: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. AP: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research and/or publication of this article. This work was supported by a grant from the "National Program for Research of the National Association of Technical Universities – GNAC ARUT 2023."

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Gen AI was used in the creation of this manuscript.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2025.1611178/full#supplementary-material

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