

Research Article

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Why Have We Failed to Narrow the Gender Gap in STEM Fields in Higher Education? Analyzing The Role of Prior Education, Mentoring, and Male Participation

M. Yolanda Burgos-López , Luis H. González-Guerra , M. Ileana Ruiz-Cantisani , Gabriela Ortiz-Martínez , Jorge Membrillo-Hernández

Abstract

Background/purpose. Women remain underrepresented in STEM, particularly in higher education, where cultural and structural barriers persist. In Mexico, women make up less than 30% of students in engineering and technology programs, highlighting a persistent gender gap. This study investigates whether gender-focused mentoring, specifically female empowerment and male allyship, can positively influence women's interest and persistence in STEM fields.

Methods. Three interrelated studies were conducted at a university in Mexico. Study 1 evaluated a six-month corporate mentorship program involving 210 undergraduate women in STEM. Study 2 assessed the attitudes and participation of 100 male students and faculty in equity initiatives. Study 3 implemented a longitudinal mentoring program for 42 high school girls from vulnerable communities, guided by undergraduate mentors and female faculty members in STEM fields. Each study used a mixed-methods approach, combining surveys, interviews, and thematic reflection analysis.

Results. Corporate mentoring increased confidence and reaffirmed STEM career intentions for 84% of participants. In Study 2, male participants reported greater awareness and support for equity, though barriers included limited awareness. In the high school case, mentoring sparked an interest in STEM among 30% of students and improved their soft skills. However, socioeconomic challenges, such as limited parental support and inadequate access to technology, persisted.

Conclusion. Mentoring programs can significantly influence women's persistence in STEM, especially when combining empowerment with inclusive male engagement.

1. Introduction

The global urgency to build inclusive, innovative, and sustainable knowledge economies has thrown a sharp spotlight on persistent gender disparities in science, technology, engineering, and mathematics (STEM) (Fox, 2005; UNESCO, 2017). Although women now outnumber men in overall higher education enrollments worldwide, they represent fewer than one in three researchers and remain particularly underrepresented in engineering, computing, and applied technology fields (UNESCO, 2017). Recent meta-analyses confirm that female participation not only declines at each educational and career transition point, known as the "leaky pipeline," but also remains stalled in many regions despite decades of interventions (Smith & White, 2025; Ayyildiz & Banoglu, 2024).

1.1. Expanding efforts beyond women-only programs

Traditional remedies, such as scholarships, one-off mentoring schemes, or short diversity workshops, have yielded local successes yet rarely achieve system-level change (Freedman et al., 2023). A growing body of scholarship now argues that focusing solely on women is insufficient; instead, the wider academic community, especially men in positions of influence, must become active partners in dismantling bias and reshaping cultural norms (Shaju et al., 2024; Ceci & Williams, 2011). Evidence from Australia, the United States, and Northern Europe suggests that well-designed allyship initiatives can increase male awareness, reduce microaggressions, and enhance departmental climates (Kim & Meister, 2023). However, evaluations of such programs remain sparse, small-scale, and heavily skewed toward Anglo-American contexts.

1.2. A Neglected Geography: Latin America

In Latin America, and Mexico in particular, the gender gap is equally pronounced but under-researched. National statistics indicate that women make up < 30 % of students in engineering and technology, a proportion virtually unchanged since 2010 despite multiple public–private campaigns (Secretaría de Educación Pública [SEP], 2023; Ortiz-Martínez et al., 2023). Structural obstacles, limited early exposure to science, entrenched stereotypes, a lack of female role models, and uneven regional labor demand continue to impede progress. Moreover, although mentoring programs are often celebrated as retention tools, they frequently lack continuity, scalability, or rigorous evaluation (Msambwa et al., 2024; Shaju et al., 2024). Very few studies simultaneously investigate women-centered interventions and male ally engagement within the same institutional ecosystem, leaving a critical knowledge gap on how these strategies interact.

1.3. Addressing the gap

This study responds to that gap by examining three interlinked initiatives at a large, multi-campus Mexican university:

1. Industry-based mentoring for female undergraduates in STEM.
2. Allyship training for male students and faculty.
3. Longitudinal mentoring for girls from socio-economically vulnerable communities.

Using a mixed-methods, multi-study design, we assess how these layered interventions affect motivation, retention intentions, and attitudes toward gender equity. By situating our analysis in Mexico, a region largely absent from the international STEM (Verdugo-Castro et al., 2022; Makarova et al., 2019), equity evidence base, we extend current scholarship in four ways:

- Provide Latin-American data on both women-targeted and male-ally programs.
- Compare industry-versus-academic mentoring models across a six-month horizon.
- Integrate AI-supported data analysis to explore emerging methodological opportunities.

- Offer policy-relevant insights for scaling inclusive STEM initiatives within contexts marked by pronounced regional and socio-economic diversity.

1.4. Study purpose

Our overarching aim is therefore two-fold: (a) to test whether combining female-focused mentoring with deliberate male engagement can accelerate cultural change in STEM faculties, and (b) to generate evidence-based recommendations for universities and policymakers seeking to close the gender gap in Latin-American STEM education. By addressing an empirically documented yet geographically underrepresented issue, this research offers fresh perspectives on the global discourse on gender equity in STEM. It highlights the importance of multi-stakeholder, context-sensitive strategies for achieving lasting transformation.

2. Literature Review

2.1. Factors behind the Gender Gap in STEM

Contemporary literature attributes the STEM gender gap primarily to social and cultural factors rather than innate ability differences. From an early age, girls and boys are influenced by gender norms and stereotypes circulated by parents, teachers, peers, and media (Smith & White, 2025). These stereotypes often label STEM as “masculine” and suggest that girls are less naturally adept in these fields. Over time, such messages can undermine girls’ confidence and interest in math and science. Indeed, studies have found that girls’ lower participation in STEM is the outcome of self-selection shaped by socialization and implicit biases, rather than a biological inability. For example, Cheryan et al. (2017) reviewed common explanations for gender disparities. They found that women’s especially low representation in fields like physics, engineering, and computer science is tied to three key factors: (a) masculine cultural norms in those fields that signal women do not belong, (b) a lack of early exposure and experience to spark interest and skills, and (c) gender differences in self-efficacy or confidence. Crucially, when girls do not see female role models in STEM or encounter environments that feel exclusionary, they are more likely to conclude, “STEM is not for me” and opt out. Large-scale international assessments echo this: in countries (like Mexico) where teen girls underperform boys in science and math, they also report far less interest in STEM careers. Entrenched societal expectations, often reinforced by family and teachers, steer young women away from technical fields, resulting in a persistent gender gap in STEM studies.

2.2. Role of Teachers and Educational Climate

Teachers and the overall learning environment play a crucial role in shaping girls’ engagement with STEM. Research shows that having female STEM teachers and mentors can positively influence girls’ performance, confidence, and likelihood of pursuing further STEM studies.

Girls also benefit when educators adopt inclusive teaching strategies, connect STEM content to real-life contexts, and maintain high expectations for all students, regardless of gender. In contrast, when teachers hold biased beliefs, such as assuming boys are inherently better at math, or providing unequal attention and feedback, girls’ STEM learning experiences can suffer. Early educational experiences send powerful signals: supportive classroom environments and encouragement can enhance girls’ self-efficacy in STEM. At the same time, subtle discouragement or stereotyping can lead girls to lose interest as they grow older.

To counteract bias, many experts advocate for teacher training in gender-inclusive pedagogies. It is crucial to ensure that textbooks and curricula showcase female scientists and avoid stereotypical representations to help girls “see” themselves in STEM roles. In summary, teachers and schools can uphold the status quo or act as change agents to ignite and sustain girls’ interest in STEM from

primary school through college from primary school through college (Dabić et al., 2024; Wang & Eccles, 2013).

2.3. Initiatives in Higher Education to Recruit and Retain Women in STEM

Higher education institutions have increasingly implemented programs to encourage more women to enter STEM majors and to reduce attrition among female students. A variety of intervention strategies have shown promise in the literature (Ortíz-Martínez et al., 2023; Stout et al., 2011; Beede et al., 2011).

Key approaches include:

- **Mentoring and Role Models:** Pairing female STEM students with mentors and showcasing successful women scientists and engineers helps foster a sense of belonging and aspiration. Mentorship programs have been found to boost women's confidence, motivation, and understanding of STEM career pathways. For example, a study at a Mexican university identified mentorship and regular talks by women professionals as valuable steps to encourage women to continue in STEM programs (Browning et al., 2025; Stelter et al., 2021).
- **Peer Support Networks:** Creating female student groups, clubs (e.g., Society of Women Engineers chapters), or cohort programs allows women to share experiences and strategies, reducing feelings of isolation. Strong peer relationships can improve persistence by providing social support and combating the "only girl in the class" effect (Barrios-Martínez et al., 2023).
- **Inclusive Teaching and Advising:** Universities train faculty to employ active learning and collaborative projects to engage all students. Instructors and academic advisors are encouraged to check for implicit bias and actively promote women in STEM courses. Awareness workshops for faculty (highlighting issues like stereotype threat and microaggressions) have been proposed to make STEM departments more welcoming (Stelter et al., 2021).
- **Structural Supports:** Some institutions offer bridge programs and tutoring for incoming STEM students, which can be particularly beneficial for those from underrepresented groups. Others offer scholarships or financial incentives to women in technical fields. Flexible policies (such as parental leave for graduate students or convenient campus childcare) can also help retain women who might otherwise leave STEM due to outside responsibilities (Sebastián-Tirado et al., 2023).

Evidence suggests that multifaceted programs combining these elements are most effective. A 2023 systematic review of interventions found that relatable role models, supportive peer groups, "gender-neutral" (inclusive) classroom climates, and direct education about gender bias were among the most successful components for improving women's STEM outcomes. Many universities now pursue comprehensive strategies to address the complex factors influencing female students' recruitment and retention in STEM (Beede et al., 2011; Freedman et al., 2023; Verdugo-Castro, García-Holgado, et al., 2022; Wang & Eccles, 2013).

2.4. Role of Academic Institutions and Policies

Academic authorities and policymakers play a crucial role in advancing gender equity in STEM through effective policy and leadership. University administrations can set the tone by prioritizing diversity and inclusion, for instance, hiring more female faculty in STEM departments (providing students with role models and mentors) and enforcing zero-tolerance policies for gender discrimination or harassment on campus (Wang & Eccles, 2013; Wang & Degol, 2013). Developing formal diversity action plans or task forces ensures accountability in improving campus climate. At a higher level, government and educational authorities have introduced initiatives such as national scholarship programs for women in STEM fields, public awareness campaigns, and K-12 outreach programs targeting girls (Abbas et al., 2024). In Latin America, a holistic approach has been

advocated, involving the improvement of science education in schools, the fostering of public-private partnerships to support the training and recruitment of women, and the implementation of family-friendly policies in workplaces to facilitate women's transitions from education into STEM careers. Such integrated responses, engaging schools, universities, employers, and communities, are necessary to tackle deep-rooted gender gaps. Crucially, women themselves should be involved in designing and leading these solutions. Studies note that when educational institutions actively promote STEM for women (through mentorship, curricula reform, and policy), it moves us closer to gender equality in education and ultimately helps "create a more inclusive, equitable and sustainable world" (Barrios-Martínez et al., 2023; Ceci & Williams, 2011).

2.5. Engaging Men as Allies in STEM

Because men still comprise the majority of STEM faculty, students, and professionals, the male population has a significant role in fostering a more gender-equitable environment (De Souza & Schmader, 2022). Recent discourse has emphasized male allyship, which involves men actively supporting and advocating for women in STEM fields. Research suggests that when men speak up for gender equity – for example, by publicly crediting women's ideas, challenging biased comments, or mentoring junior female colleagues – they can be powerful agents of culture change, partly because their interventions are less likely to be self-serving. Male allies can help normalize the presence of women in STEM and share the work of combating sexism. However, engaging men in these efforts can be challenging. Many men do not fully recognize the extent of bias their female peers face or may fear saying the "wrong" thing (Bianchi et al., 2025). Some mistakenly view gender equality as a zero-sum game that threatens their prospects. To overcome this, organizations and universities have begun to offer ally training workshops to educate male students and faculty about unconscious bias and effective partnership in diversity efforts. When male leaders and colleagues actively promote inclusive norms (ensuring women are heard in meetings or included in projects), it sends a strong signal that everyone belongs in STEM. In short, cultivating male allies – from the classroom to the boardroom – is a key piece of the puzzle in achieving gender parity (Closon & Nyssen, 2025).

2.6. Consequences of Women's Underrepresentation in STEM

The underrepresentation of women in engineering and science has broad consequences for innovation, economic development, and social progress (Sachdev, 2018); Cracking the Code: Girls' and Women's Education in Science, Technology, Engineering. Labor Market Impacts: In many countries, STEM jobs are among the fastest-growing and highest-paying; when women are underrepresented in these fields, they miss out on economic opportunities, and the industry loses access to half of its talent pool. A 2024 World Economic Forum report noted that underutilizing female STEM talent holds back economic growth, and increasing women's participation in STEM careers could significantly boost productivity and GDP. In Mexico, for instance, only about 8% of women work in STEM occupations (versus 27% of men), which indicates a vast reservoir of potential talent not contributing to high-demand sectors (<https://www.weforum.org/stories/2023/01/davos23-gender-equality-stem-support-sustainable-economy/>). This gap contributes to gender wage disparities and can hinder countries' competitiveness in an increasingly technology-driven world.

2.7. Innovation and Sustainable Futures

A less visible but critical consequence is the impact on innovation and the relevance of solutions produced by STEM fields. Diverse teams have been shown to spur greater creativity by bringing various perspectives to problem-solving. Research agendas and product designs may reflect a narrower worldview when women scientists and engineers are missing. There are well-documented cases of this bias: for example, heart disease was long studied mainly in males, leading to misdiagnosis of symptoms in women, and car safety features were historically designed for the "average" male

body, resulting in higher injury risks for female passengers. Similarly, modern artificial intelligence systems have demonstrated troubling biases when the teams developing them lack diversity. Including more women in STEM is not just about equity; it tangibly improves outcomes – it broadens the scope of inquiry. It helps ensure that technologies and innovations meet the needs of all people (“Women in Stem Cell Science,” 2018; Verdugo-Castro, Sánchez-Gómez, et al., 2022). Moreover, many of today’s global challenges (climate change, public health, and sustainable energy) require the brightest minds to tackle them from every segment of society. If half the population is discouraged from fully participating in STEM, losing ideas and perspectives can slow progress toward solutions. In contrast, empowering women in STEM has a multiplier effect, driving scientific discoveries, creating more robust and user-friendly technologies, and bringing social benefits that move us closer to a sustainable future for all (Andrijevic et al., 2020).

2.8. Latin America and Mexico: Regional Perspectives

Viewed globally, Latin America and the Caribbean (LAC) present a mixed picture, with some strides made in women’s STEM education amid continuing challenges (Zepeda Pérez & Villagómez Valdés, 2021). On the one hand, LAC outperforms many regions in terms of the share of women in STEM graduates – roughly 41% of STEM degree holders in the region are female, which is higher than the global average of ~35-38%. Countries like Argentina, Brazil, and Uruguay have seen a growing enrollment of women in fields such as biology, medicine, and certain branches of engineering. However, this educational progress has not fully translated into workplace equity. Across LAC, women remain a minority in STEM employment (e.g., only ~30% of ICT jobs in the region are held by women) (Lara-Prieto et al., 2023) (Pradier et al., 2024). In Mexico, women comprise less than 20% of engineering professionals, and as noted, only a small fraction of Mexican women end up working in STEM occupations (Ortiz-Martínez et al., 2023) (Pacheco Figueroa & Alvarez Lemus, 2025). Cultural norms and biases present in the broader society can be a significant barrier; machismo and traditional gender roles may dissuade women from pursuing technical careers or create hostile work environments that drive them out. Additionally, fewer networking opportunities and persistent wage gaps in STEM fields deter the retention of those women who do enter (López-Caudana et al., 2025).

To counter these trends, several initiatives have emerged in Latin America. Governments and NGOs have launched programs to spark girls’ interest in science from a young age (for example, coding clubs and science camps targeted at girls). Universities in countries such as Mexico, Colombia, and Chile have established women in STEM networks (Ingenia at our higher education institution) to support female students and researchers through mentoring and professional development (Lara-Prieto et al., 2023). There is also an increasing emphasis on intersectionality – recognizing, for instance, the need to support indigenous and rural women in STEM via scholarships and community-based programs. These efforts align with calls from international organizations (UNESCO, UN Women, etc.) to adopt comprehensive measures: reforming educational content, training teachers on gender sensitivity, engaging families to encourage girls, and improving work–life policies so that more women can sustain STEM careers. While challenges remain, the regional momentum is growing. By addressing gender gaps in STEM, Latin American countries can advance equality and benefit economically and technologically from the fuller inclusion of their female population.

3. Methodology

This paper presents a synthesis of findings from three interrelated studies conducted within an extensive, multi-campus private university system in Mexico. These studies collectively examine the design, implementation, and outcomes of gender-focused educational interventions aimed at promoting greater inclusion and equity in STEM education. A mixed-methods research design was employed, integrating quantitative approaches, such as surveys, with qualitative techniques, including open-ended responses and narrative reflection. This methodological triangulation allowed

for a comprehensive understanding of the interventions' impact on different stakeholder groups. This research is part of a larger study on the causes of the low percentage of female students in STEM fields. These three case studies illustrate three key aspects of this global problem, helping us understand and design new strategies for the future.

3.1. Study 1: Corporate Mentorship for Female Students

The first study examined the outcomes of a structured mentorship program designed explicitly for undergraduate women enrolled in STEM fields (science, technology, engineering, and mathematics). A total of 210 female students voluntarily participated in a six-month initiative, where each participant was paired with a mentor from the corporate sector, specifically professionals working in industries aligned with the students' fields of study.

The evaluation strategy included administering pre- and post-program surveys using a 5-point Likert scale (1 = completely disagree to 5 = agree). The survey instruments measured key variables, including academic motivation, self-confidence in professional competencies, perceived clarity of career goals, and attitudes toward long-term engagement in STEM fields. To complement the quantitative data, participants submitted reflective narratives at the end of the mentorship program, detailing their personal experiences, perceived benefits, and challenges encountered.

Thematic analysis of these narratives was conducted using an inductive coding approach to identify recurring patterns related to empowerment, role modeling, professional identity development, and institutional support. This dual-method approach facilitated a robust interpretation of how mentorship influences female students' persistence in STEM pathways.

3.2. Study 2: Male Participation in Equity Initiatives

The second study aimed to assess the levels of awareness, involvement, and willingness to participate in gender equity initiatives among male members of the academic community. The study population included 100 participants, comprising both faculty members and undergraduate students from STEM and social science disciplines.

Participants completed a structured questionnaire that assessed familiarity with gender equity concepts, prior involvement in equity-promoting activities, and openness to participating in future efforts. The instrument also captured perceived institutional support and the perceived relevance of gender equity to academic and professional environments.

In addition to the survey, qualitative data were collected through open-ended prompts that asked respondents to reflect on their motivations for supporting (or not supporting) gender equity, perceived social or cultural barriers to involvement, and any shifts in perspective resulting from prior exposure to diversity training or inclusive pedagogical practices.

Responses were subjected to qualitative content analysis, with a focus on identifying themes such as allyship, resistance, transformation, and performative engagement. This study offered valuable insight into the role men can play in advancing gender equity and the institutional mechanisms required to foster meaningful participation.

3.3. Case Study: Mentoring Model for Students in Vulnerable Communities

The third study employed a longitudinal case study methodology to investigate the impact of a multi-phase mentoring program targeting female students from socially and economically disadvantaged communities. The intervention spanned across four progressive educational stages, designed to provide continuous support from early secondary school through to high school graduation.

- **Phase 1:** Motivational Engagement and STEM Exposure.

This initial phase targeted 1st-year middle school students through weekend workshops focused on motivation, self-efficacy, and introductory STEM activities. The aim was to generate early interest in science and engineering while cultivating a growth mindset and aspiration-building.

- **Phase 2:** Academic Tutoring.

For 2nd-year students, the program offered weekly academic support in core subjects—Mathematics, Spanish, and Science. These sessions were facilitated by trained university students and teaching assistants and were designed to address learning gaps while promoting inquiry-based learning approaches.

- **Phase 3:** High School Entrance Preparation.

During their final year of middle school, 3rd-year students participated in intensive preparatory sessions for high school entrance exams. This phase included diagnostic assessments, development of study skills, and personalized academic guidance to maximize student success in transitioning to upper-secondary education.

- **Phase 4:** High School Mentorship and Personal Development.

The final phase extended support to participants who successfully entered public high school. These students received continuous mentoring with a focus on personal development, identity construction, and academic perseverance. The topics included leadership, emotional regulation, communication skills, and vocational exploration, all framed within the context of continuing STEM engagement.

Data collection for this case study included attendance records, pre- and post-surveys of self-efficacy, mentor reports, and student focus groups. The evaluation examined not only academic progression but also psychosocial development, identity affirmation in STEM contexts, and the perceived sense of belonging within educational spaces.

This holistic mentoring model emphasized sustained engagement and was developed with a strong equity lens to counteract structural disadvantages. By embedding culturally relevant pedagogies and maintaining long-term mentor-student relationships, the program aimed to bridge systemic gaps and foster inclusive educational continuity.

3.4. Ethical Considerations and Limitations

All three studies received institutional ethical approval. Participants were fully informed of the research's purpose and their rights to confidentiality and withdrawal. The data were anonymized, and special care was taken when working with minors in the case study, ensuring parental consent and collaboration with the school district.

One limitation of the studies is their focus on a single private university network, which may limit their generalizability to public or rural educational contexts. Nonetheless, the diversity of participants in terms of socio-economic backgrounds and geographical reach across campuses contributes to a nuanced understanding of gender-focused interventions in higher education.

4. Results

4.1. Corporate Mentorship Outcomes

We believe that the companies and industries that usually employ our graduates may serve as a potential ally to promote an increase in the number of Female students in STEM careers. Therefore, we asked female CEOs of training partners or executive directors who could serve as mentors to our female students to study whether this might increase their interest in STEM careers. Figure 1 shows

a flowchart that visualizes the outcomes of a mentoring program conducted for 210 female students from the School of Engineering and Sciences. The program aimed to empower these students, with mentors being CEOs and general managers from various companies and industries. The graphic illustrates the process from the initial stage of pairing students with mentors to the outcomes at the end of the semester.

The first section of the flowchart shows that 63% of the mentors were women, and 37% were men. This data emphasizes the importance of gender diversity in the mentoring process, as both male and female role models are integral in shaping students' perspectives and career choices. The flowchart then moves to the description of the mentoring sessions, which lasted 30 to 60 minutes and took place once a month. This regular, but not overly frequent, interaction allowed consistent guidance without overwhelming the students or mentors.

At the end of the semester, students were asked to provide feedback on their experiences. The majority (90%) of the students reported that their experience with the mentoring program was good, while only 5% found it bad, and another 5% did not provide an answer. When asked why they would recommend the experience to others, 50% cited a change in perspective, 35% found the experience enriching, and 15% deemed it motivating. These findings highlight how the mentoring program influenced the students' outlook on their career prospects, with many feeling more empowered and open-minded about their professional future.

Lastly, a significant outcome of the program was that 92% of students would recommend the experience to others, and 84% reported that the program helped them reaffirm their decision to pursue a career in STEM. These high percentages underscore the effectiveness of mentorship in shaping and reinforcing the career choices of female students in STEM fields.

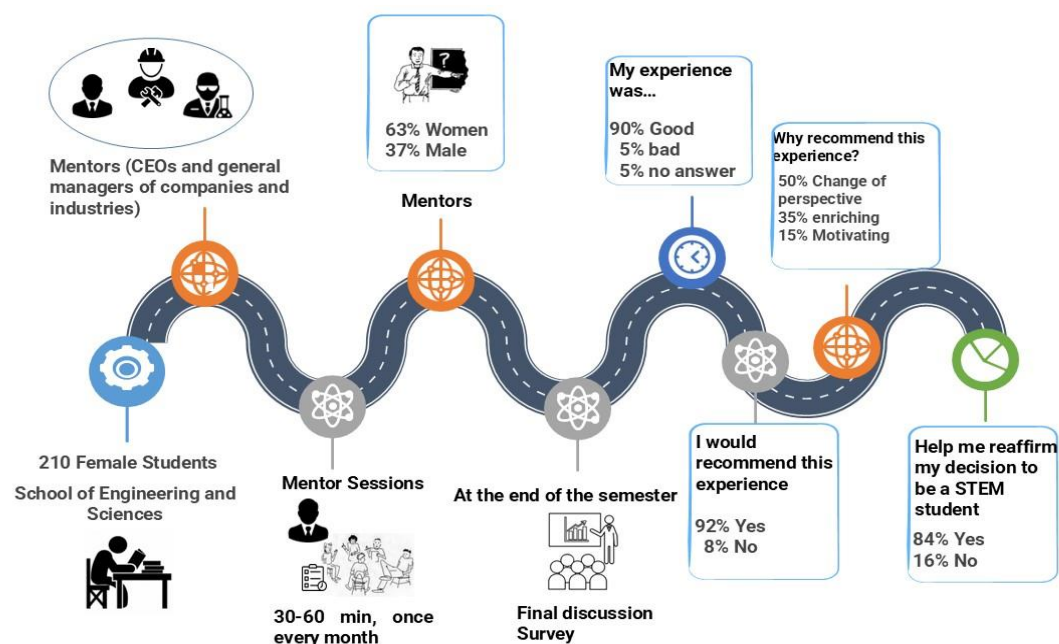


Figure 1. Flowchart of Corporate Mentoring Program for Female STEM Students.

This figure illustrates the mentoring process for 210 female students from the School of Engineering and Sciences, paired with CEOs and general managers as mentors. The chart displays the gender distribution of mentors (63% female, 37% male) and the structure of the mentoring sessions (30-60 minutes, once a month). The program outcomes are highlighted: 90% of students reported a positive experience, 92% would recommend the experience, and 84% reaffirmed their decision to pursue a career in STEM. Additionally, students emphasized the program's impact on changing perspective, enrichment, and motivation.

4.2. Male Engagement Outcomes

To study the influence and perspective of the male population on female students' choice of STEM careers, we performed the strategy depicted in Figure 2. The flowchart presents the survey responses of 100 male participants regarding their involvement in gender-equity initiatives, with a particular focus on perceptions of gender equality in the workplace, especially in STEM fields. The survey results are divided into two main groups: those who participated in gender-equity initiatives (78 participants) and those who did not (22 participants). Each response category is visualized using colored boxes and arrows, leading to a deeper understanding of the participants' perspectives.

4.2.1. Participation and Motivation

Among the 78 participants involved in gender-equity initiatives, the majority (57%) cited genuine interest as their reason for participation, while 43% were invited by a friend. This shows a high level of intrinsic motivation, with peer influence also playing a significant role. This insight suggests that gender-equity initiatives appeal to those interested in the topic and individuals who might initially join due to external encouragement.

4.2.2. Perceptions of Gender Equality

The chart highlights contrasting perceptions of gender equality. When asked if they thought women have the same opportunities as men, 36% of the participants responded affirmatively, while 64% disagreed, indicating a perceived lack of equality in gender opportunities. Furthermore, when evaluating the importance of gender-equity initiatives, 86% of participants believed these efforts should reduce the gender gap, and 50% thought it was vital to raise awareness of women's abilities in STEM fields. These numbers reflect a strong commitment to addressing gender disparities, particularly in areas like STEM, where the underrepresentation of women is still a significant issue.

4.2.3. Non-Participation Group

The chart also examines why 22 participants did not engage in gender-equity initiatives. The most significant percentage (48%) were unsure or did not know about the opportunities, 28% were not invited, and 14% were not interested. This suggests a combination of lack of awareness and opportunity, highlighting potential areas for intervention in outreach and accessibility for future initiatives.

100 Male survey responses

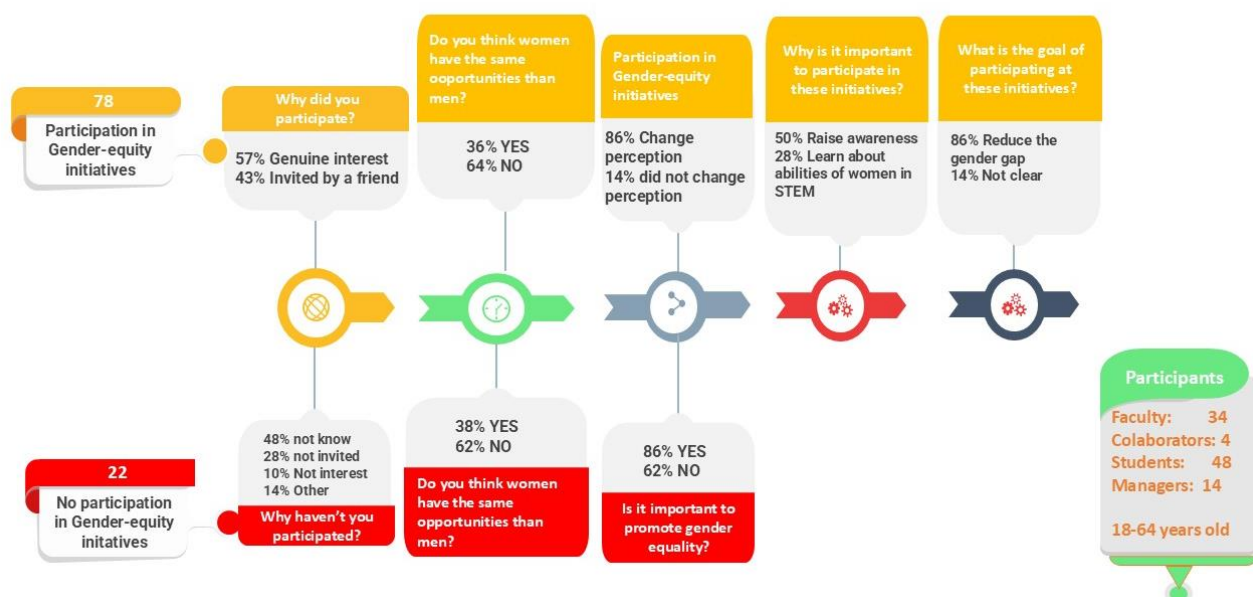


Figure 2. Survey Responses of 100 Male Participants on Gender-Equity Initiatives.

This flowchart visualizes the participation, motivations, perceptions, and goals of 100 male survey respondents regarding gender-equity initiatives. It categorizes participants into two main groups: those involved in gender-equity initiatives (78 respondents) and those not involved (22 respondents). The chart tracks motivations for participation, perceptions of gender equality, and views on the importance of gender-equity programs in STEM, ultimately emphasizing the desire to reduce the gender gap and raise awareness of women's capabilities in traditionally male-dominated fields.

4.3. Students in Vulnerable Situations

The flowchart of Figure 3 provides a step-by-step outline of a mentoring study conducted with female high school students in a vulnerable community in northern Mexico. It illustrates the study context, the Participants involved, the weekly Structure of mentoring activities, the Data Collection methods, and the key Outcomes observed. Each box represents one of these sequential elements, connected linearly from Context through Outcomes.

4.3.1. Context

The study occurred in a vulnerable community in northern Mexico, focusing on female high school students. The goal was to assess how various socioeconomic factors influence students' decisions to pursue careers in STEM (Science, Technology, Engineering, and Mathematics). This context sets the stage for understanding the challenges and environments from which these students come.

4.3.2. Participants

Forty-two female high school students participated as mentees in the program. Each student was paired with an undergraduate student mentor who guided the study. Additionally, 15 female teachers from STEM fields were involved to lead weekly workshops and conferences. These teachers served as role models and facilitators, reinforcing the mentoring through structured STEM learning experiences.

4.3.3. Structure

The mentoring program's structure was organized on a weekly cycle with three main components:

- **Mentor–Student Meetings:** Each mentor met one-on-one with their mentee on a weekly basis to discuss academics, personal development, and career aspirations.
- **STEM Workshops/Conferences:** The participating teachers conducted weekly group sessions, focusing on STEM topics and hands-on activities to spark interest and build skills.
- **Mentor–Teacher Feedback Meetings:** Mentors and teachers convened weekly to exchange feedback on student progress, address challenges, and tailor upcoming sessions to each student's needs.

This consistent weekly structure ensured continuous support and allowed adjustments based on ongoing feedback.

4.3.4 Data Collection

At the end of the program, researchers collected data to evaluate the impact of the mentoring. Two primary methods were used:

- **Interviews:** Each student participated in an end-of-program interview, providing qualitative insights into their experiences, changes in perspective, and overall feedback on the mentoring program.

- **Questionnaires:** Students also completed detailed questionnaires covering their academic preferences, outlook on the future, aspects of their personal lives, access to technology, and expectations from education and careers. These surveys captured quantitative and categorical data to complement the interview findings.

Combining interview and questionnaire data enables a comprehensive analysis of both subjective experiences and objective factors influencing career choices.

4.3.5. Outcomes

The study yielded several noteworthy outcomes regarding the students' career intentions and the effects of the mentoring intervention:

- **STEM Career Interest:** By program's end, about 30% of the students indicated plans to pursue STEM careers (an increase compared to the start), while roughly 66% preferred fields in Business or Social Sciences. This indicates a moderate increase in STEM interest, although a majority still leaned toward non-STEM paths.

- **Skill and Personal Development:** The mentoring experience helped students improve empathy, responsibility, and time management. Many mentors reported growth in their mentees' confidence and soft skills throughout the program.

- **Challenges Identified:** Despite the gains, students continued to face persistent challenges. Common issues included limited technological access, heavy family responsibilities (household roles), financial constraints, a fear of or intimidation by STEM subjects, and a lack of parental support for higher education. These socioeconomic and cultural barriers often influenced the students' ability to engage fully in STEM activities.

- **Support Needs:** The feedback highlighted critical areas where students needed extra support. Notably, approximately 50% of the students requested additional help with Mathematics, and around 30% sought guidance on time management skills. These areas were key to bolstering their confidence and success in pursuing STEM education.

Overall, the mentoring program had a positive impact on the participants, sparking an interest in STEM for some and developing valuable life skills for many. However, the outcomes also underscored the importance of addressing external barriers, such as resource limitations and cultural expectations, to improve the representation of young women from vulnerable communities in STEM fields.

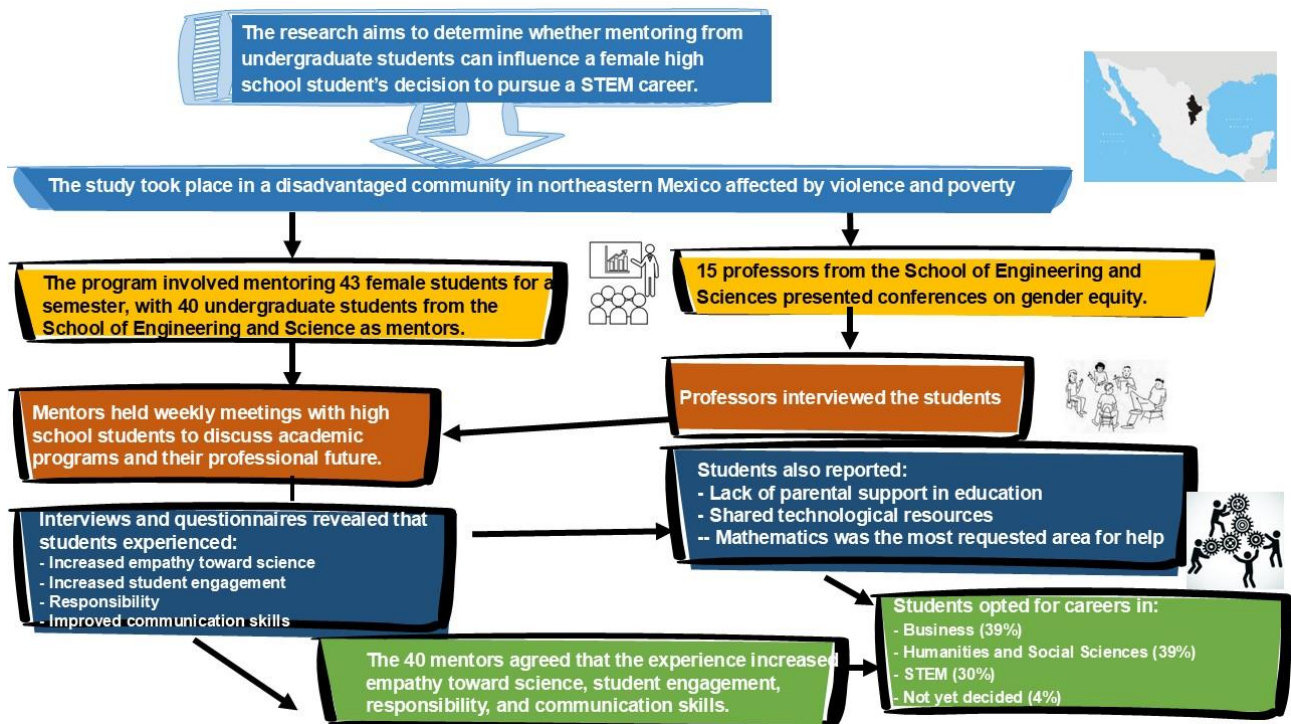


Figure 3. Flowchart of a Mentoring Program for Female High School Students in Northern Mexico.

This figure outlines the structure and outcomes of a mentoring program designed to influence the career choices of female high school students in a disadvantaged community in northeastern Mexico. The program involved 43 female students, mentored by 40 undergraduate students, and included weekly one-on-one mentoring sessions and gender equity conferences led by 15 professors. Data from interviews and questionnaires indicated significant improvements in student engagement, empathy toward science, and communication skills. Despite the positive impact, the students' career preferences leaned toward business and humanities/social sciences, with a smaller proportion choosing STEM fields.

5. Discussion

Female underrepresentation in STEM fields, particularly engineering, is a complex problem influenced by social norms, educational barriers, and workplace challenges (Beede et al., 2011; Fox, 2005). Addressing these disparities requires a multifaceted approach that includes educational reforms, mentoring, workforce policies, and targeted financial support (Expanding Underrepresented Minority Participation, 2011). By fostering an inclusive and supportive environment, society can empower more women to pursue and excel in STEM fields, ultimately leading to a more diverse and innovative workforce in the future.

Several studies have examined the perspectives of male students on the underrepresentation of females in STEM fields. Understanding these views is crucial to developing effective strategies to promote gender diversity in these areas. This study designed and validated an instrument to assess college students' views on gender in STEM. This research highlighted that personal motivations, academic background, and societal influences play a key role in students' perceptions of STEM. Although the study included both male and female students, it focused on gender-related perceptions to prevent horizontal gender segregation in higher education.

Mentoring young women in high school yielded data demonstrating that classroom dynamics can influence students' career aspirations. Some students revealed that girls are less likely to consider science a viable career when taught alongside confident peers. At the same time, boys in the same environment may be more motivated to pursue science. This suggests that peer confidence may have

a differential impact on the STEM interests of male and female students. The opinions of senior-level female mentors in companies indicate that, despite serving as role models for students, the interviewees believe that to achieve the same level of success, they must endure a path of sacrifices that many are unwilling to undertake. However, seeing the recognition and the progress in gender equality and equity greatly motivated them, and they would like to share it with other students.

The socioeconomic and cultural context affects women's decision to pursue a STEM career due to the sexist view that women do not have to study "complex sciences" or that the workforce is only for men. Mentoring young women from the School of Engineering and Science helped them understand the weakened social values that many women experience when living in conflict zones. Our data suggests that if there are no job prospects for them in STEM fields near the communities where they study, STEM careers will not be favored by the enrollment of women from those communities.

5.1. Corporate Mentoring for Female Undergraduates in STEM

Our six-month, one-to-one mentoring scheme improved Mexican students' motivation, confidence, and clarity about career pathways. Comparable gains have been reported in recent Latin American pilots, for example, a STEM mentorship program at UJAT (Universidad Juárez Autónoma de Tabasco) in Tabasco, in the south of Mexico, where structured mentor matching, goal setting, and digital communication were central design features (Pacheco Figueroa & Alvarez Lemus, 2025; Meoli et al., 2024). Unlike the Austrian and German cases summarized by the Society of Women Engineers, which rely mainly on academic mentors, our model draws exclusively on industry professionals, exposing mentees to real-world workplace cultures and expectations (Brizuela et al., 2023). Furthermore, most published STEM-mentoring studies last only eight to twelve weeks; by spanning two academic terms and incorporating reflective writing, we captured richer mid-range developmental trajectories in a majority-minority Latin American setting, which is seldom represented in the global evidence base.

5.2. Engaging Men as Allies

Studies in Australia and the United States show that male students and faculty become genuine partners in equity initiatives when training integrates self-reflection with clear, low-threshold opportunities for action (O'Shea, 2018; Matthews, 2018). Our results mirror those outcomes but differ in two key respects:

- Sample heterogeneity: We included early-career lecturers and undergraduates, whereas most research on allyship focuses on senior academics in STEM departments.
- Triangulated measurement: Beyond Likert-scale surveys, we analyzed narrative prompts, allowing us to quantify attitudinal shifts while also exploring stories of resistance and transformation.

These contrasts suggest that ally training can begin earlier in the pipeline and that mixed-methods instruments capture nuances that are missed by interview-only designs.

5.3. Longitudinal Mentoring in Vulnerable Communities

Multi-year outreach programs, such as iBEARS and several LACCEI regional projects, emphasize sustained support during key educational transitions (Hilson, 2023; Ruiz-Cantisani et al., 2023). Our intervention extends this literature by (i) scaffolding students across three breakpoints (early secondary, high-stakes entrance exam, upper secondary) and (ii) coupling academic tutoring with psychosocial workshops, an element rarely detailed in U.S. longitudinal STEM studies. Early evidence suggests higher retention in upper-secondary STEM tracks compared to state averages, underscoring

that long-term, community-embedded mentoring is crucial for achieving equity in low-income contexts.

5.4. Cross-Study Synthesis

Taken together, the three investigations demonstrate that a portfolio approach, combining industrial mentoring, male ally engagement, and phase-based academic support, can reinforce positive outcomes within a single university ecosystem. Whereas much of the literature isolates one dimension at a time (e.g., mentorship or allyship), our research addresses multiple actors (women, men, and vulnerable youth) and multiple time scales (semester-long to multi-year). Embedding the work in a private Latin American network also reveals contextual factors, family expectations, scholarship dependence, and campus culture, which are seldom discussed in Anglophone studies.

6. Limitations

Several constraints temper our conclusions:

1. External validity – All data were collected in a single, urban, private university system; results may not generalize to public or rural institutions.
2. Self-selection bias – Participation was voluntary; individuals predisposed to gender-equity ideals were more likely to enrol, particularly in the ally cohort.
3. Self-reported measures – Motivation, confidence, and attitude changes were assessed via surveys and reflections that remain susceptible to social-desirability effects, despite triangulation.
4. Limited longitudinal horizon – The corporate mentoring study followed students for only two semesters; the long-term career impacts remain unknown.

7. Future Perspectives

To strengthen evidence and maximize impact, future work should:

1. Scale and diversify contexts – Replicate the interventions in public universities and technical colleges to test adaptability in resource-limited settings.
2. Adopt quasi-experimental designs – Employ control groups or difference-in-differences methods to infer causal effects more robustly.
3. Extend longitudinal tracking – Follow participants for eight to ten years to examine graduation rates, employment trajectories, and leadership outcomes.
4. Incorporate hybrid and AI-supported mentoring – Explore digital platforms for mentor matching and remote guidance, expanding reach to remote regions at a lower cost.
5. Deepen intersectional analysis – Study how gender intersects with ethnicity, disability, or socio-economic status, especially in Indigenous and rural communities.
6. Forge industry partnerships – Align with local employers to create internships and first-job pipelines, mitigating the talent drain from women who return to communities lacking STEM opportunities.

Pursuing these directions will sharpen our understanding of how comprehensive, context-sensitive equity programs can drive sustainable changes in STEM education across Latin America and beyond.

8. Conclusion

If we have been studying this phenomenon for 50 years, why haven't we managed to increase the number of women in STEM fields significantly? The common factor lies beyond the classroom: in

the family, home, and social environment. Our efforts towards a more equal society must focus on comprehensive approaches that involve other social actors, local governments, stakeholders, and employers committed to providing a secure and inclusive employment outlook for women's development. Public policies that begin in the family, extend to schools, and extend beyond the workplace will alter these numbers and increase the female presence in STEM. Our studies have been thorough, and we hope they will serve as a foundation for future research on women in STEM.

Declarations

Author Contributions. All authors contributed equally to all stages of the research process, including conceptualization, design, data collection, analysis, and manuscript preparation. All authors were actively involved in conducting literature synthesis, thematic analysis, and structuring the theoretical framework. All authors reviewed and approved the final version of the manuscript.

Conflicts of Interest. The authors declare that they have no conflict of interest.

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