Jurnal Hurriah: Jurnal Evaluasi Pendidikan dan Penelitian
Hurriah Journal: Journal of Educational Evaluation and Research
Volume 7, No. 2 (2026) PP 279-291

Jurnal Hurriah: Jurnal Evaluasi Pendidikan dan Penelitian
Hurriah Journal: of Educational Evaluation and Research

Journal homepage: https://academicareview.com/index.php/jh
E-ISSN: 2774-8472 I P-ISSN: 2774-8480 I DOI : 10.56806

Women in STEM and TVET: A Systematic Review of Participation, Barriers, and Career Development (2022–2026)

Muhammad Akbar[1], Nurhasan Syah[2*], M.Giatman[2]

[1] Doktor of Technology and Vocational Education Degree Programme, Universitas Negeri Padang, Padang , Indonesia.
[2] Departement of Civil Engineering, Universitas Negeri Padang, Padang, Indonesia.

ARTICLE INFO

Article history:
Received: April, 2026
Received in revised from: May, 2026
Accepted : June, 2026
Available online: July, 1, 2026

Keywords: STEM, TVET, women, gender equality, career development, women's participation, systematic literature review.

ABSTRACT

In the era of digital transformation and the green economy, women's participation in STEM fields as well as Technical and Vocational Education and Training (TVET) is essential to achieving gender equality and meeting labour market needs. Gender differences in STEM education and employment continue to exist in many countries despite various laws intended to boost women's involvement. The purpose of this project is to investigate research trends, participation types, obstacles, and career development tactics for women in STEM and TVET between 2022 and 2026. The PRISMA 2020 guidelines were followed for conducting a Systematic Literature Review (SLR). Using keywords like women, STEM, TVET, gender equality, and career development, articles were located in the ScienceDirect database. The results show that there has been an upsurge in study on women in STEM and TVET, with an emphasis on career development, mentorship, role models, gender hurdles, and women's involvement. Gender stereotypes, discrimination, poor self-efficacy, and restricted access to mentors and professional networks are the most commonly mentioned obstacles. Strengthening mentorship programs, offering female role models, fostering digital capabilities, and enacting more equitable labour and education laws are among suggested tactics. The findings of this study have significance for developing gender-equitable vocational education programs that support women's long-term employment in STEM fields.

1. Introduction

Digital transformation, the Fourth Industrial Revolution, and technology-driven economic development have reshaped the competency requirements of the global workforce. These conditions demand mastery of STEM competencies and vocational skills relevant to future industrial developments. In this framework, TVET acts as a strategic instrument for developing a workforce with technical, digital, and adaptable skills matched with the requirements of the current labour market (Parua & Yang, 2024). Additionally, by integrating education with industrial demands, TVET improves employability (Cai & Kosaka, 2024). In contrast to males, women are still under-represented in engineering, technology, and vocational education, despite the growing demand for STEM jobs. Because women's under-representation can impede productivity, creativity, and variety of viewpoints in knowledge-based economic growth, this issue is of worldwide significance (Sevilla et al., 2023).

* Corresponding author.
E-mail address: nurhasan@ft.unp.ac.id
https://doi.org/10.56806/ jh.v7i2.442

Although many nations have enacted gender equality rules in school, the gender gap in STEM disciplines remains a major concern. According to various studies, social stereotypes that associate science, technology, engineering, and mathematics with men can influence women's perceptions of their own abilities and identities within STEM, reducing their interest in pursuing academic programs or careers in these fields (Sebastián-Tirado et al., 2023);(Starr & Leaper, 2023). Inadequate social support and a dearth of female role models also influence women's choices to work in STEM fields. It has been discovered that having female role models dispels gender stereotypes, fosters a feeling of community, and inspires women to seek STEM careers and education (Tal et al., 2024). Therefore, improving social support and expanding female representation are crucial factors in efforts to reduce the gender gap in STEM fields. Gender stereotypes still have a significant impact on women's educational and career decisions in Indonesia, according to research on gender dynamics in STEM. Because of this, women are more likely to work in social services, education, and health than in technology and engineering (Warsito Warsito, Nur Choiro Siregar, aris gumilar, 2023).

TVET programs that emphasise engineering and technology are similarly impacted by the gender gap, which is not limited to STEM education in general. Women are still under-represented in vocational programs in engineering, manufacturing, computer technology, and construction, according to a number of surveys. The institutional barriers that prevent women from enrolling in vocational STEM programs are still not sufficiently addressed by TVET rules in many developing countries (Wignall et al., 2023). Furthermore, a research on engineering TVET in South Africa suggests that the engineering learning environment remains male-dominated, resulting in women regularly encountering marginalisation and constraints in accessing equal learning opportunities (Machaka & Singh-Pillay, 2025). This situation highlights that increasing access to education alone is insufficient without policy and cultural transformations that support women's participation (Amegah, 2022).

Women confront several challenges to pursuing and sustaining professions in STEM. Gender stereotypes, discrimination, poor self-efficacy, restricted professional networks, and a dearth of female mentors in engineering and technology are among the impediments (Silva et al., 2023);(Cuthbert et al., 2023);(Williams et al., 2025). According to Social Cognitive Career Theory (SCCT), women's career development is significantly impacted by external factors like employment opportunities, learning experiences, educational environments, and family support through self-efficacy and outcome expectations (Lent et al., 1994);(Byars-Winston & Rogers, 2019). The study (Sevilla et al., 2023) found that institutional and social barriers affect female students' career advancement in STEM-TVET programs more than they do male students. Similar findings were seen in the context of STEM education in Indonesia, showing that women's learning experiences and interest in STEM fields are still influenced by gender perspectives, technological availability, and learning environment assistance (Noviyanti et al., 2025).

Women encounter a number of obstacles not just in their academic pursuits but also in the advancement of their STEM careers after they enter the field. According to several studies, women are more susceptible to the "leaky pipeline" problem, which occurs when fewer women pursue STEM careers at every level because of a variety of institutional and cultural obstacles (Tal et al., 2024). These problems include limited career opportunities, gender discrimination in companies, challenges juggling work and family obligations (work-life balance), and a dearth of women in leadership positions (Casad et al., 2021). Women often have to overcome self-doubt, imposter syndrome, and professional identities shaped by gender norms and macho organisational cultures, according to research on women's careers in the ICT and IT sectors (Williams et al., 2025).

These conditions may hinder women's ability to grow in their careers and secure strategic or leadership positions in the STEM fields (Silva et al., 2023).

Most research still focuses on barriers to participation, gender stereotypes, or the gender representation gap in isolation, while studies that integrate aspects of participation, barriers, and career development for women in STEM and TVET remain relatively limited (Amegah, 2022). Furthermore, the development of the green economy, digital transformation, and future workforce needs have increased the demand for STEM competencies and technical skills, making women's participation a strategic issue in supporting inclusive and sustainable economic development (Parua & Yang, 2024). As a result, a Systematic Literature Review (SLR) is required to synthesise the most recent empirical research on developments in women's involvement, impediments, and career development strategies in STEM and TVET between 2022 and 2026. The findings of this study are intended to give a more thorough knowledge and lay the groundwork for the creation of more inclusive and gender-equitable vocational education policy (Page et al., 2021). The research questions are as follows:

1. RQ1. What are the research trends on women in STEM and TVET for the years 2022-2026?
2. RQ2: How do women participate in STEM and TVET education/careers?
3. RQ3: What constraints and enabling variables impact women's involvement and career development in STEM and TVET?
4. RQ4: What measures can increase gender equality and women's career development in STEM and TVET?

2. Methodology

In order to identify, assess, and synthesise research findings on women's participation, obstacles, and career development in STEM (Science, Technology, Engineering, and Mathematics) and TVET (Technical and Vocational Education and Training), this study employs the Systematic Literature Review (SLR) method. Numerous facts, statistics, and information gathered from scientific sources, including articles and relevant research journals, were analysed in order to complete the literature review (Akbar et al., 2026).The SLR method was selected because it can produce a methodical, clear, and repeatable synthesis of scientific data that provides a comprehensive view of the development of a research problem. Additionally, SLR enables researchers to use empirical data to identify research trends, gaps, and future research directions (Snyder, 2019);(Xiao & Watson, 2019). The PRISMA 2020 guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), an international standard for reporting systematic reviews to enhance transparency and research quality, were followed during the literature review process in this investigation (Page et al., 2021).

2.1 Literature Search Strategy

Since it affects the calibre, applicability, and thoroughness of the articles that will be examined, the literature search process is a crucial stage in a Systematic Literature Review (SLR). In order to find articles about women's participation, obstacles, and career growth in STEM and TVET from 2022 to 2026, the search strategy for this study was carefully designed. To guarantee that the article identification process was transparent, methodical, and repeatable by other researchers, the search was conducted in compliance with PRISMA 2020 guidelines (Page et al., 2021). The ScienceDirect database served as the major source for literature searches in this investigation. ScienceDirect was chosen because it is one of the largest international databases for credible scientific papers in a variety of fields, including education, STEM, engineering,

technology, social sciences, and vocational education. Additionally, ScienceDirect has a broad journal coverage and is widely used in higher education research and systematic reviews because it provides articles that have undergone a peer-review process.

Once the keywords have been identified, the next step is to construct a search string using Boolean operators (AND, OR) to link various research concepts.

The OR operator is used to combine synonyms with similar meanings, while the AND operator is used to narrow the search so that the articles found contain all the required concepts. The main search string used is:

Table 1. Research Results Database

Keywords	Database	Results
("women in STEM") AND OR TVET OR "vocational education") AND ("career development" OR employability OR "career pathways") AND ("gender equality" OR "gender equity"	Science Direct	14.534

2.2 Inclusion and exclusion criteria

The inclusion and exclusion criteria must be precisely set in order to verify that the papers analysed are actually related to the study subject. The format shown below is often used for SINTA and Scopus publications.

Table 2. Inclusion and Exclusion Criteria Table

Inclusion criteria	Exclusion criteria
1. Publication Year (2022–2026)	1. Duplicate Article
1. Publication Type (Research Article)	2. Irrelevant Topic
3. Database (ScienceDirect)	3. Not Open Access
4. Open Access	
5. Language: English	
6. Research Focus (Gender, Women, STEM, TVET, Career Development)	

The articles used in this study were chosen based on inclusion criteria, which included empirical research articles published between 2022 and 2026, written in English, indexed in ScienceDirect, available in full text, and discussing women's participation, barriers, enabling factors, or career development in STEM and TVET. Conversely, articles published before 2022, those irrelevant to the research focus, editorials or conceptual articles, those not available in full text, and duplicate articles were excluded from the analysis. Following the selection procedure, each article was appraised using a quality evaluation tool to guarantee the validity and relevance of the findings that would be synthesised. Figure 1, the PRISMA flowchart, provides further details.

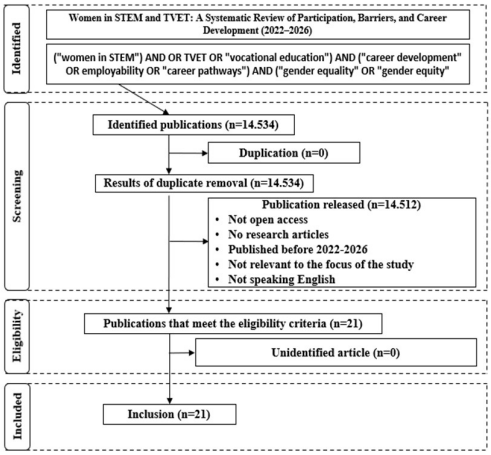

Fig.1. Prism method for article search

3. Results

Based on the authors' research, using the keywords ("women in STEM") AND OR "TVET" OR "vocational education") AND ("career development" OR employability OR "career pathways") AND ("gender equality" OR "gender equity"), a comprehensive search was conducted in databases such as ScienceDirect, identifying 14,512 articles relevant to the keywords used, based on abstracts and titles that met our specific criteria. A total of 21 papers were chosen for this systematic review based on all inclusion criteria, which were classified as follows: articles published within the previous 5 years, open-access articles, research articles, and articles related to the theme and field of vocational and technical education. All papers that did not fulfil these criteria were removed and did not go on to the next round of examination. Table 3 shows the list of articles that have been approved for the next stage.

Table 3. Synthesis Summary of Articles received from 2022-2026

No	Author	Year	Country	Context
1	Ana Santiago-Vela , Alexandra Mergener. (Santiago-Vela & Mergener, 2022).	2022	Germany	In the context of the modern labor market, this study specifically highlights the gender gap in overeducation.
2	Sara Bonesso, Federica Bressan. (Sara & Federica, 2026).	2026	Italy	The topic of gender disparity in STEM (science, technology, engineering, and mathematics) fields is discussed, with an emphasis on how women advance and stay in their jobs to become leaders.
3	Sherry Bawa, Subramaniam Ananthram, Dawn Bennett , Subhadarsini Parida. (Bawa et al., 2024).	2024	Australia	The relationship between STEM skills, professional skills (soft skills), and gender differences in perceived employability among college students.
4	Kevin A. Hoff, Kenneth E. Granillo-Velasquez, Alexis hanna, Mike Morris, Hannah S. Nelson, Frederick I. Oswald. (Hoff et al., 2024).	2024	United States of America	The study environment focuses on efforts to better understand the disparities in professional interests between men and women, as well as their relationship to gender

No	Author	Year	Country	Context
				representation in the workplace.
5	Yannan Gao, Jacquelynne S. Eccles, Anna-Lena Dicke. (Gao et al., 2025).	2025	United States of America	Regarding gender disparities in STEM education and employment, specifically how men and women seek and sustain STEM occupations from adolescence to early adulthood.
6	Azzurra Meoli, Evila Piva, H´ erica Righi. (Meoli et al., 2024).	2024	Italy	the subject of gender differences in STEM fields (science, technology, engineering, and mathematics), particularly when moving from college to the workforce.
7	Andreas Kuhn, Stefan C. Wolter. (Kuhn & Wolter, 2022)	2022	Switzerland	The phenomenon of gender segregation in job selection and vocational education, particularly within the apprenticeship system in Switzerland.
8	Budi Waluyo, Anita, Akhirudin, Darisy Syafaah, Moh. Buny Andaru Bahy. (Waluyo et al., 2025).	2025	Indonesia	The issue of gender awareness and gender equality in language education at Indonesian universities.
9	María Paola Sevillaa, Paola Bordónb, Fernanda Ramirez-Espinozac. (Sevilla et al., 2023).	2023	Chile	The topic of gender disparities in STEM within Vocational and Technical Education (VTE), notably at the secondary level in underdeveloped nations.
10	Yuliya Kosyakova, Zerrin Salikutluk, Jorg Hartmann. (Kosyakova et al., 2023).	2023	Germany	the assimilation of refugees into the German workforce, with a focus on gender disparities in employment after forced migration.
11	Alexandra Wicht, Nora Müller, Reinhard Pollak. (Wicht et al., 2024).	2024	Germany	The link between changes in job duties, gender disparity, and salary trends in today's labour market, particularly during the digital transition.
12	Richard Nennstiel, Rolf Becker	2025	Switzerland	There is a relationship between the expansion of education, gender equality, and employment status in the Swiss labor market over a period of approximately five decades.
13	Daniele Nascimento Silva, Wesley Douglas Oliveira Silva, Marcele Elisa Fontana. (Silva et al., 2023).	2023	Brazil	Gender disparity in STEM fields, where women are still under-represented in comparison to men, especially in leadership and strategic positions.
14	Ross Wignall, Brigitte Piquard, Emily Joel. (Wignall et al., 2023).	2023	UK	The Technical and Vocational Education and Training (TVET) system in Sub-Saharan Africa, particularly in Cameroon and Sierra Leone, is rife with gender inequity..

No	Author	Year	Country	Context
15	Manuel Morales Valero, Sergio Moldes-Anaya, Diana Amber Montes, cristina Cruz Gonzales. (Morales Valero et al., 2025).	2025	Spain	Women entrepreneurs play a key role in rural Spain by assisting local economic growth and tackling rural depopulation.
16	Jonas Detemple. (Detemple, 2025)	2025	Germany	Higher education graduates' geographical mobility and its association with economic success after joining the labour market
17	Fahmida N. Chowdhury. (Chowdhury et al., 2021).	2021	United States of America	the importance of gender parity in the workplace, especially in historically male-dominated fields like science, technology, engineering, and mathematics (STEM).
18	Lidia de Castro Romero, Víctor Martín Barroso, Rosa Santero-Sanchez. (de Castro Romero et al., 2025)	2025	Spain	issues with gender equality in the hospitality industry, particularly the gender pay gap in managerial positions in a number of European countries.
19	Christina Boateng. (Boateng, 2024)	2025	Ghana	In Ghana's Cape Coast Metropolis, gender disparities exist in pre-university STEM-focused Technical and Vocational Education and Training (TVET).
20	Olubukola Oluranti Babalola, Yvonne du Plessis,Sunday Samson Babalola.(Babalola et al., 2024)	2023	South Africa	Women are still under-represented in STEM fields, especially in leadership positions in Africa.
21	Louise Kiernan, Marie Walsh, Eoin White. (Kiernan et al., 2023).	2024	Ireland	disparities between genders in STEM (science, technology, engineering, and mathematics) education, especially when students go from secondary to university education.

Publication Keyword Mapping

The co-occurrence of keywords suggests a significant association between terms within a certain category. The overlay visualisation from VOSviewer depicts a map of the evolution of research keywords related to Women in STEM and TVET: A Systematic Review of Participation, Barriers, Career Development, and Authentic Assessment. Figure 2 below illustrates this:

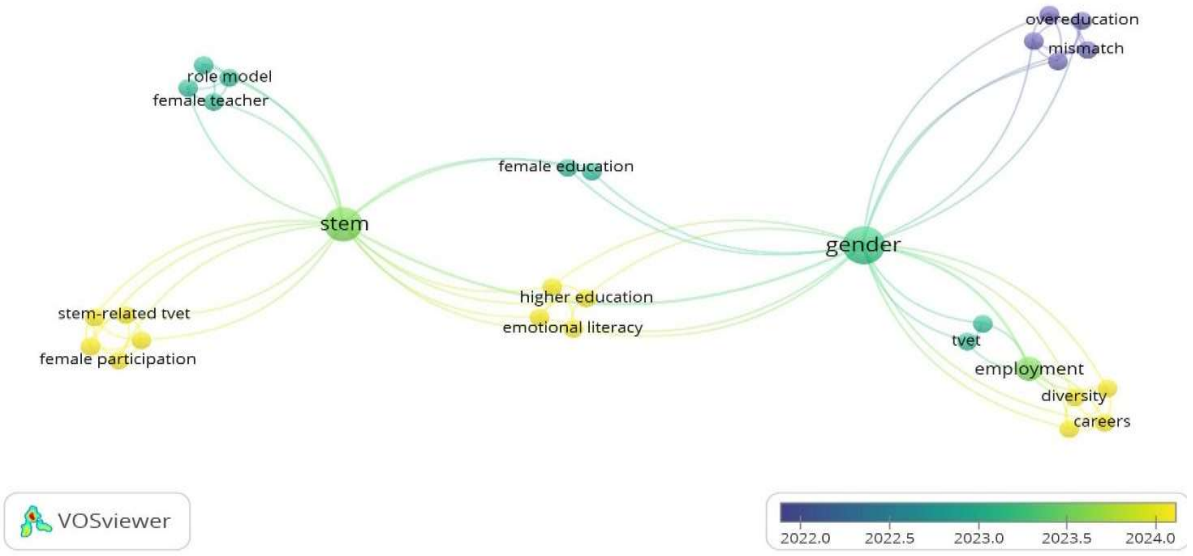

Fig.2. Bibliography based on vosviewer

The VOSviewer visualization overlay shows the development of research themes regarding women in STEM and TVET during the 2022–2024 period. It is evident that the keywords “gender” and “STEM” are the main themes, as they have the largest node sizes and serve as the central hubs connecting to other keywords. This implies that gender equality issues in STEM education and careers are the focus of most study. The terms "female participation," "STEM-related TVET," "female teacher," and "role model" on the left show that research regularly discusses women's involvement in STEM-based vocational education as well as the significance of female role models and teachers in encouraging women's interest in engineering and technology fields. In the center, the keywords “female education,” “higher education,” and “emotional literacy” indicate a focus on women’s educational experiences and the factors supporting their academic success. Meanwhile, on the right side, keywords such as “employment,” “careers,” “diversity,” and “TVET” indicate a shift in research focus toward career development, workforce diversity, and employment opportunities for women after completing STEM or TVET education. Based on the color gradation, topics such as “overeducation” and “mismatch” were more frequently studied in the early period (2022), while “female participation,” “careers,” and “diversity” emerged as newer themes (2023–2024). These findings indicate that research is shifting from concerns of access and gender disparities to methods for enhancing women's involvement and career sustainability in STEM and TVET. The following questions are relevant to this research:

RQ1. What are the research trends on women in STEM and TVET for the years 2022-2026?

Research on women in STEM (Science, Technology, Engineering, and Mathematics) and TVET (Technical and Vocational Education and Training) fields rose dramatically between 2022 and 2026, according to the literature review. Growing awareness of gender equality concerns throughout the world, digital change, the necessity for a workforce that relies on technology, and the sustainable development agenda which promotes women's involvement in STEM and vocational education all contribute to this surge. (Sevilla et al., 2023); (Amegah, 2022); (Cai & Kosaka, 2024). Research on women's low involvement in STEM and TVET, as well as the many obstacles they face, was conducted between 2022 and 2023. Common issues that are becoming more prevalent include gender stereotypes, discrimination, cultural standards, low self-efficacy, and restricted opportunities for

education and work. Numerous studies indicate that women's involvement in engineering and technology education is still significantly hampered by the perception of STEM as a male-dominated field (Amegah, 2022).

Moving into the 2023-2024 decade, the study focus shifted to elements that may increase women's engagement. Female role models, mentoring, institutional support, and inclusive learning settings are among the top goals. According to research, women's motivation, interest, and career aspirations in STEM fields are greatly enhanced by the presence of female role models (De Gioannis et al., 2023);(Tal et al., 2024). Additionally, research will concentrate more on career development, workforce diversity, employability, and opportunities for women in technology and the green economy between 2024 and 2026. These results imply that research now focuses on creating strategies and policies to support women's participation and career sustainability in STEM and TVET, rather than just identifying obstacles (Vásquez-Chaux et al., 2025):(Afshari et al., 2024).

RQ2. How do women participate in STEM and TVET education/careers?

Although there is still a gender imbalance, a review of the literature reveals that women's participation in STEM (Science, Technology, Engineering, and Mathematics) and TVET (Technical and Vocational Education and Training) education and careers has increased recently. The increasing number of students and college students choosing STEM degrees, particularly in science, health, and information technology, is indicative of women's involvement in education. Nonetheless, there are still extremely few women working in engineering, manufacturing, construction, and industrial technology. Various studies indicate that women tend to participate more in STEM fields perceived as having a social orientation, while male-dominated engineering and technology fields still face challenges in attracting women's interest (Sevilla et al., 2023); (Amegah, 2022).

In TVET education, women's participation is reflected through their involvement in skills training programs, STEM-based vocational education, and competency enhancement programs to enter the workforce. Nevertheless, participation remains unevenly distributed, as women more frequently choose administrative, service, and health programs over engineering and technology programs.
Low female presence in engineering-based TVET programs is mostly caused by cultural issues, gender stereotypes, and a lack of female role models (Amegah, 2022); (Vásquez-Chaux et al., 2025). In industries like technology, engineering, manufacturing, and STEM, women are actively involved in the workforce. But obstacles still stand in the way of women's access to professional networks, leadership positions, and opportunities for growth. To expand women's involvement, initiatives must focus not just on educational access, but also on career sustainability through mentorship assistance, competency development, and legislation that encourage gender equality in the STEM and TVET industry (Afshari et al., 2024); (Tal et al., 2024).

RQ3. What constraints and enabling variables impact women's involvement and career development in STEM and TVET?

Women's participation and career development in STEM (Science, Technology, Engineering, and Mathematics) and TVET (Technical and Vocational Education and Training) are impacted by a number of barriers and enabling factors, according to the literature review. The most commonly mentioned obstacle is gender stereotypes, which maintain that men are more qualified for fields like science, technology, engineering, and mathematics than women. These preconceptions can impact educational choices, impair self-efficacy, and limit women's job goals as young as school age (Sevilla et al., 2023);(Amegah, 2022). Women also face challenges such as gender discrimination, a dearth of

female representation in engineering and technology professions, and restricted prospects for leadership roles in the STEM industry.

Other barriers include limited access to female mentors, low social support, and a lack of professional networks that could aid career development. Several studies indicate that male-dominated educational and workplace environments often make women feel less accepted and deprive them of equal opportunities for growth (Williams et al., 2025); (Vásquez-Chaux et al., 2025). Low retention rates for women in STEM education and STEM-related jobs may be caused by several factors. Conversely, there are several factors that encourage women's participation and success in STEM and TVET. These variables include the availability of female role models and mentors, familial support, an inclusive learning environment, and gender equality-promoting institutional policies. Mentoring programs, skill development, and career literacy campaigns have all been found to increase women's motivation, self-esteem, and readiness to pursue STEM fields. Therefore, attempts to expand women's involvement require not only the removal of structural barriers, but also the improvement of long-term support structures so that women may thrive and remain in STEM and TVET fields (De Gioannis et al., 2023); (Tal et al., 2024).

RQ4. What measures can increase gender equality and women's career development in STEM and TVET?

A multifaceted approach at the individual, educational institution, industry, and government policy levels is required to improve gender equality and women's career development in STEM (Science, Technology, Engineering, and Mathematics) and TVET (Technical and Vocational Education and Training), according to the literature review. One of the most commonly advised techniques is to provide female role models and mentorship programs. The presence of female lecturers, professors, practitioners, or leaders in STEM disciplines has been found to increase women's motivation, self-confidence, and career goals to enter and remain in historically male-dominated industries. Mentoring programs can also assist women get the intellectual, social, and professional support they need throughout their careers (De Gioannis et al., 2023); (Tal et al., 2024).

The second strategy is to create an inclusive, gender-neutral learning environment. Curricula, teaching strategies, and school cultures that support women's participation in STEM and TVET must be offered by educational institutions. Various studies indicate that gender stereotypes which view engineering and technology fields as male-dominated professions remain a major barrier for women. Therefore, gender awareness campaigns, training for educators, and the integration of a gender equality perspective into learning are crucial steps to increase women’s engagement perempuan (Sevilla et al., 2023);(Amegah, 2022). Additionally, strengthening career development and future-ready competencies is a highly important strategy. Women can have greater access to employment prospects and career progression in the STEM field through upskilling and reskilling programs, enhanced digital literacy, professional networking, and collaborations between TVET universities and industry.Achieving gender equality and long-term careers in STEM and TVET requires policies that support workforce diversity, leadership opportunities for women, and fair access to training and employment in the context of digital revolution and the green economy (Afshari et al., 2024); (Tal et al., 2024).

4. Conclusions

The topic of women in STEM (Science, Technology, Engineering, and Mathematics) and TVET (Technical and Vocational Education and Training) is becoming more prominent in the academic literature, according to the results of a comprehensive literature review of papers published between 2022 and 2026. Research trends show a shift away from highlighting gender gaps and poor female involvement and toward wider conversations about enabling factors, career development, workforce diversity, and methods for increasing women's participation in STEM and vocational education. These findings show that gender equality is no longer only about educational access; it is also about career sustainability and women's employment possibilities.

The study's conclusions also show that women still face a number of obstacles to STEM and TVET education and careers, such as discrimination, gender stereotypes, low self-efficacy, restricted access to mentors and role models, and a lack of institutional support. Due to these barriers, women are under-represented in traditionally male-dominated fields like engineering, technology, and STEM. However, a number of studies have discovered that women's motivation, engagement, and career success in these fields may be enhanced by social support, an inclusive learning environment, the availability of female mentors, and gender-responsive laws.

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