

Addressing Gender Disparity in STEM School Education: A Systematic Review with Thematic Synthesis



Dr. Nidhi Bansal

Assistant Professor, Department of Humanities and Social Sciences
Malaviya National Institute of Technology, Jaipur (Rajasthan)

Abstract

The underrepresentation of females in STEM fields has been a long-standing concern, varying in magnitude and reasons, in different socio-economic and cultural contexts. Despite growing academic interest in investigating females' underrepresentation in STEM education, little is known about how school-level dynamics influence females' motivation and participation in STEM careers ultimately. The present study aims to provide a systematic review and thematic synthesis of the research on STEM education at the school level in the domain of social science that examines the underrepresentation of females. The study employs systematic review and thematic scrutiny to: understand the key characteristics of research studies in the field of STEM school education; identify the key themes of research work in the field of STEM school education; and identify the research gap and propose potential future research areas. The Scopus database was searched using a set of Boolean keywords, and after thorough screening based on the inclusion and exclusion criteria, a total of 212 articles were identified and retrieved for analysis. The selected articles were thoroughly reviewed for recurrent patterns and themes. The study contributes to providing a comprehensive understanding of global research trends, key themes and proposes future research directions in the context of the underrepresentation of females in STEM education at the school level. The findings inform educators, practitioners and policymakers in cultivating the equal representation of females in STEM education.

Keywords: Underrepresentation, STEM, School, Education, Thematic Synthesis, Review

Introduction

The underrepresentation of women in STEM (science, technology, engineering and mathematics) is an enduring issue. It has been argued that the underrepresentation of women in STEM leads to an absence of requisite diversity in the workforce (Patrick et al. 2009; Yabas et al. 2022; Chiang et al. 2023). Addressing underrepresentation of women in STEM is vital to achieving sustainable development goals (SDGs) (Mérida-Serrano et al. 2020; Wang et al. 2023; Buenestado-Fernendaz 2023). Besides, substantial literature has examined the socio-economic implications of the leaky

pipeline and glass ceiling in STEM, which contribute to attrition of women at different stages of education and career. The underrepresentation diminishes the opportunities for women to enter into high-paying jobs (Patrick et al. 2009, Hsieh et al. 2017), leads to the generation of untapped resources, that could meet the need for a skilled labor force (Roue, 2014), affects the economic development of the countries and women themselves (Rowan and Lynch, 2011, Niño-Cortés et al. 2023), negatively affects the self-development and self-attainment of females and risks losing a potential labor force in the field of science (He

et al. 2019). It has been argued that there is an increasing demand for STEM professionals in the global marketplace (Patall et al. 2018) and that women make up a large proportion of the workforce, and thus, they have to be trained to be competitive and integrated in the global economy (Etim & Gindeel, 2015). The existing literature has shown that it is important to address the issue of the underrepresentation of women in STEM and the leaky pipeline at the school level. For instance, Ergün (2019), who conducted a study at a middle school level in Turkey, has argued that STEM career goals are taken during middle school years. In another study based in the context of the United States, Simpkins et al. (2015) argued that high school is a significant point in the STEM trajectory because gender disparities in occupational pursuits start emerging from the level of high school. However, there is paucity of research analysing STEM education at the school level in the context of India. For instance, Sahoo and Klasen (2021), who have conducted their study using nationally longitudinal data from India, have shown that girls are twenty per cent less likely than boys to opt for science and commerce streams than humanities at the senior secondary level. It indicates gender differences in the field of STEM, early at the school level.

Rationale

Recently, increasingly scholarly attention has been directed towards the underrepresentation of women in STEM education and the workforce. There is noticeable research in the domain of higher education, the scientific community, and the STEM workforce with regard to this lopsided representation of women, but the context of school education has not received much academic attention. Given that several research studies have documented that the formation and development of science identity and gender differences in the context of STEM education often begins at the school level, it becomes imperative to develop a comprehensive understanding of the role of gender within school-based educational contexts. It becomes essential to addressing systemic challenges at later stages of education.

The present study attempts to address this research gap. It aims to offer an overview by employing thematic analysis and providing an in-depth understanding of the key research trends in the field of STEM school education, and provides future research directions. Table 1 presents a list of review papers published in the domain of STEM school education. However, it is noteworthy that none of these adopts a thematic analysis approach to examine the underrepresentation of females in STEM education within school settings.

Table I: List of review papers published in the domain of STEM school education

Title of the paper	Authors	Year of Publication	Databases referred	Duration	Number of records re-viewed	Type of Study	Focus
Systematic review: The impact of pedagogy on equity in science education in rural schools	Jalak, J. T., & Nasri, N. M.	2019	Google Scholar, ERIC and SAGE	10 years (2009-2018)	10	Systematic literature review	pedagogical impact on equity in science education in rural schools
STEM initiatives matter: Results from a systematic re-	Prieto-Rodríguez, E., Sincok, K., & Black	2020	EBSCO Proquest Scopus Web of Science	39 years (1980-2018)	32	Systematic literature review	STEM-related interventions, Secondary

Title of the paper	Authors	Year of Publication	Databases referred	Duration	Number of records re-viewed	Type of Study	Focus
view of secondary school interventions for girls	more, K.						school education
Motivational factors that influence student science achievement: A systematic literature review of TIMSS studies	Zhang, F., & Bae, C. L.	2020	PsycINFO (American Psychological Association), Academic Search Complete (EBSCOhost), Web of Science (Core Collection), ERIC (Education Resources Information Center), and EBSCO (Education Research Complete)	10 years (2011-2020)	15	Systematic literature review	Students' science achievement, School education
The role of parent's beliefs in students' motivation, achievement, and choices in the STEM domain: a review and directions for future research	Šimunović, M., & Babarović, T.	2020	Web of Science, Educational Research Information Center [ERIC], Science Direct, and Google Scholar	-	54	Comprehensive review (Thematic analysis)	Parent-child interaction in STEM
Gender gaps in science: systematic review of the main explanations and research agenda	Tomassini, C.	2021	Web of Science	34 years (1985-2018)	53	Systematic review	Students' STEM performances, Students' STEM learning experiences, and students' STEM occupational expectations at school level

Title of the paper	Authors	Year of Publication	Databases referred	Duration	Number of records re-viewed	Type of Study	Focus
Gendered differences versus doing gender": a systematic review on the role of gender in CSCL	Kube, D., Weidlich, J., Jivet, I., Kreijns, K., & Drachsler, H.	2022	ScienceDirect (Elsevier), SAGE, and SpringerLink	17 years (2005-2021)	27	Systematic literature review	Impact of Computer supported collaborative learning in STEM education on gender equality
A review of ICT-enabled learning for school-girls in Asia and its impacts on education equity	Liang, M., Lim, C. P., Park, J., & Mendoza, N. B.	2022	Education Resources Information Centre (ERIC), JSTOR Archive Complimentary Collection, Scopus and Web of Science	12 years (2010-2021)	30	Systematic literature review	Equity in school education, ICT-enabled learning
A systematic review of the factors affecting girls' participation in science, technology, engineering, and mathematics subjects	Msambwa, M. M., Daniel, K., Lianyu, C., & Fute, A.	2023	Web of Science, Scopus, EBSCO-host, and Google Scholar	11 years (2013-2023)	165	Systematic literature review	Environmental, behavioral and personal factors participation in STEM subjects
Interventions for gender equality in STEM education: A meta-analysis	Yu, W., He, J., Luo, J., & Shu, X.	2024	ERIC, IEEE, JSTOR, ProQuest-Education, SAGE Journals, Scopus, Springer Link, Taylor & Francis, Web of Science, and Wiley Online Library	16 years (2007-2022)	23	Systematic literature review	Different forms of interventions for gender equality in STEM education
A Systematic Review of Research on Gender Diversity in STEM Education	Hong, C. N. T., Thu, H. L. T., Huy, V. N., & Le Thi, B.	2024	Scopus	11 years (2013-2023)	42	Systematic literature review	Research on gender diversity in STEM education

Source: Compiled by the author

A number of systematic and comprehensive reviews have been conducted over the past decade to examine various dimensions of gender disparities and interventions within STEM education at the school level. Jalak and Nasri (2019), in their systematic literature review spanning a decade (2009-2018), explored the pedagogical impacts on equity in science education in rural schools by analyzing ten studies sourced from Google Scholar, ERIC, and SAGE databases. Similarly, Prieto-Rodriguez, Sincock, and Blackmore (2020) conducted a systematic review over a 39-year period (1980-2018), examining 32 records from major databases such as EBSCO, ProQuest, Scopus, and Web of Science. Their study focused specifically on STEM-related interventions targeted at secondary school girls. Zhang and Bae (2020) analyzed 15 studies published between 2011 and 2020 to investigate motivational factors influencing student achievement in science education, drawing on multiple databases including PsycINFO, ERIC, and Web of Science. Another significant contribution is by Šimunović and Babarović (2020), who carried out a comprehensive thematic review of 54 studies to explore the role of parental beliefs in students' motivation, achievement, and decision-making in STEM domains. Tomassini (2021) conducted a systematic review over a 34-year span (1985-2018), reviewing 53 studies from the Web of Science to assess gender gaps in science education, focusing on academic performance, learning experiences, and occupational aspirations among school students. In a more recent study, Kube et al. (2022) reviewed 27 articles published between 2005 and 2021 from databases such as ScienceDirect, SAGE, and SpringerLink, analyzing how computer-supported collaborative learning (CSCL) in STEM settings impacts gender dynamics. Liang et al. (2022) focused on ICT-enabled learning for schoolgirls in Asia, systematically reviewing 30 studies from 2010 to 2021 using sources such as ERIC, JSTOR, Scopus, and Web of Science to understand its influence on educational equity. Msambwa et al. (2023) provided one of the most extensive reviews by analyzing 165 articles pub-

lished over 11 years (2013-2023) from platforms like Scopus, Web of Science, and Google Scholar, to examine environmental, behavioral, and personal factors influencing girls' participation in STEM subjects. Yu et al. (2024) conducted a meta-analysis of 23 studies over a 16-year period (2007-2022), addressing various interventions aimed at promoting gender equality in STEM education by sourcing data from 11 major academic databases. Finally, Hong et al. (2024) undertook a systematic review of 42 articles from Scopus (2013-2023), focusing broadly on research trends related to gender diversity in STEM education.

The examination of extant literature in the domain indicates that despite of growing body of literature, there remains a critical gap in studies that systematically examine the underrepresentation of girls in STEM education, specifically within school-based contexts, using a thematic analysis approach. It underscores the need for comprehensive, in-depth, and contextual research in this domain.

The study formulates the following research objectives and corresponding research questions:

Objective

- Understand the current pattern of research studies in the field of STEM school education
- Identifying the key themes of research work in the field of STEM school education
- Identifying the research gap and proposing potential future research areas

Research Questions

- What are the current global trends in research studies in the field of STEM school education?
- What are the key themes of research work in the field of STEM school education?
- What research gaps exist in current research on STEM school education and what are potential future research areas?

Methodology

The present study aims to comprehend the current body of research addressing gender disparity

and underrepresentation in STEM education at school level. For this, the study adopts a thematic analysis approach and uncover the major themes and document research gaps.

Data Source and Search Strategy

To ensure the comprehensive coverage of peer-reviewed and high-quality academic literature, the Scopus database was selected as the primary source for data. The database is widely recognized for indexing standard academic research documents and using it also ensured reproduc-

ibility and methodological transparency of the present review study.

The literature search was conducted using a set of relevant keywords in the Boolean system (STEM, Gender, School, Education, disparity) and their possible synonyms. By adding identified NOT words, the results were further filtered in alignment with research objectives and a focus on STEM education at the school level and the underrepresentation of females. Table 2 presents a complete list of words incorporated in the query string for the present study.

Table II: The query string employed for the present study

Article Title, abstract, Key-words	"School" AND "STEM" OR "Science" OR "Mathematics" OR "Math" OR "Technology" AND "Primary" OR "Middle" OR "Secondary" OR "post-secondary" OR "higher secondary" AND "women" OR "girls" OR "gender" OR "female" OR "Men" OR "Boy*" AND "Underrepresentation" OR "disparity" OR "gender Gap" OR "differenc*" OR "Segregation" OR "participation" OR "equality" OR "equity" OR "inclusive" OR "Gap"
NOT words	"Higher education" OR "Cyberbullying" OR "Agriculture" OR "PhD" OR "Medical" OR "Clinic*" OR "Medicine" OR "University" OR "Physical Education" OR "Health" OR "Physical activity" OR "Dental Education" OR "Covid-19"

Inclusion and Exclusion Criteria

A total of 1496 records published after 2009 were retrieved, as the publication trend has shown a significant increase since then. All records were then screened for their relevance based on the inclusion and exclusion criteria mentioned in Ta-

ble 3, through their titles, abstracts, and keywords. Thereafter, a full-text screening of the remaining articles was conducted, and references were screened to identify relevant records; a total of 212 articles were finally included for the present study. The following criteria were used to screen the articles:

Table III: Inclusion and Exclusion Criteria

Criterion	Inclusion	Exclusion
Type of document	Peer-reviewed Journal Articles	Doctoral theses, student projects, conference proceedings, reports
Type of study	Empirical Studies based on primary data	Review studies, opinion pieces, or any other
Language	English Language	Other than the English language
Domain	Social Sciences	Other than Social Sciences
Duration	Studies published after 2009	Before 2009
Theme and focus of the document	Address the underrepresentation of females in STEM education at the School level within the school settings	Do not address the underrepresentation of females in STEM education at the School level within the school settings

Data Analysis

To address the first research question, a preliminary scrutiny was conducted to understand

the current global trend of research studies in STEM education at the school level concerning gender disparity. To answer the second research

question, the selected articles were reviewed and analysed using a thematic analysis approach as outlined by Braun and Clarke (2006). The author read the article to fully understand the context and the content. Recurring ideas were jotted down and, overarching themes started emerging. The themes were then named appropriately, and the analysis was written.

Findings

RQ1: What are the current global trends in research studies in the field of STEM school education?

Geopolitical and Geographical Contexts: Figure 1 depicts the geographical context of the studies included in the present research. Most of the work on STEM education at school levels has been carried out in the American and European contexts. In the articles that have been reviewed, around 40 percent of the studies are situated in the American context, 28 percent of the articles are situated in the European context, 20 percent of the articles are based in the Asian context, 5 percent of works are based in the Australian context, 5 percent of the work is based in the African context, 1 percent work based in the Latin American context, and 1 percent from the Middle Eastern context. Among the literature that has emerged from the Asian context, most of the works are based in China, Hong Kong, Indonesia and Turkey.

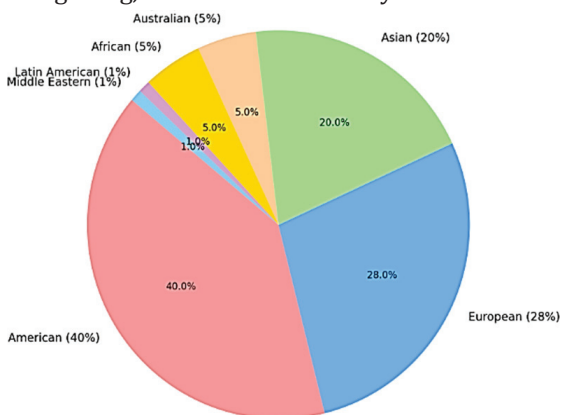


Fig. 1: Geographical Context of the Included Studies

Most of the studies are based in the urban context (Barkatsas et al., 2009; Wade-Jaimes et al., 2021). There are few studies that talk about the rural context (Gudyanga et al., 2016; Zhang et al., 2021) we intend to understand and very few articles that talk about the suburban context (Gok, 2021).

Type of Study

Out of the papers that have been reviewed, around 64 percent of the studies have used quantitative research methods, 19 percent of the studies have used mixed methods and 17 percent of the studies have used qualitative research methods. In the quantitative studies undertaken, survey questionnaires are the most commonly used research tools. Qualitative studies have predominantly used semi-structured interviews and focus group discussions. In the mixed-methods studies, both surveys, focus group discussions and semi-structured interviews have been used.

Theoretical Frameworks

Many quantitative studies have utilized the social cognitive theory (SCT) given by Albert Bandura (1986) to understand perseverance in STEM, intrinsic motivation and extrinsic motivation, self-efficacy and STEM career interests (Ng & Chu, 2021). SCT emphasizes that learning and motivation to learn are shaped by a dynamic intersection of personal factors and environmental influences. Most of the quantitative studies as well as a few qualitative studies have used the social cognitive career theory (SCCT) to understand self-efficacy in STEM, professional commitment, persistence in STEM, STEM career aspirations, intentions to pursue STEM, beliefs and attitudes towards STEM and self (Ober et al., 2024; Wang et al., 2023) SCCT provides a nuanced framework to understand how individuals develop educational and career interests and make choices based on self-efficacy beliefs, outcome expectations and personal goals. Apart from that, the Situated Expectancy Value Theory and Expectancy Value Theory have also been used in many quantitative studies to talk about the concept of STEM

career preferences or STEM career intentions. A few of the quantitative studies have also used self-determination theory to understand the motivational aspect of the students. Intersectionality theory (Erete et al., 2021) and critical race theory are the theoretical frameworks for many of the qualitative studies which seek to understand the experiences of female students from racial and ethnic minority backgrounds. Feminist theories have been used in some of the studies.

Level of School Education Studied

Out of the studies reviewed, most of the studies are based on the middle school or secondary school level. Figure 2 demonstrates that around 56 per cent of studies have taken the middle school level into consideration, 38 per cent of studies are situated at the high school level, and 24 per cent of studies have talked about primary school levels. There were a few studies which included participants from more than one level of schooling (Høgheim & Reber, 2019)

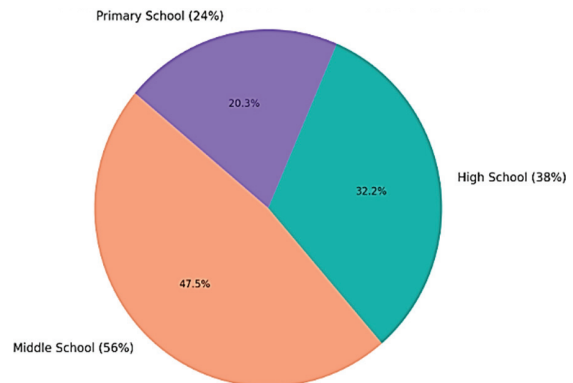


Fig. II: Level of School Education Studied

RQ2: What are the key themes of research work in the field of STEM school education?

Table 4 presents findings from the thematic analysis of the included articles. It represents the major themes identified in the current body of research concerning the underrepresentation of females in STEM education within school-based educational contexts:

Table IV: Key themes and sub-themes identified

Theme	Theme title	Sub-themes
Theme I	Attitudes Towards Gender Differences	<ul style="list-style-type: none"> Attitudes of Students Attitudes of Teachers and Educators Attitudes of Parents and Community
Theme II	Interventions to Achieve Gender Equity	Pedagogical Interventions: <ul style="list-style-type: none"> Curriculum-based (e.g., Engineering for Sustainable Communities) Teacher training Project-based learning Informal Science Learning: <ul style="list-style-type: none"> Science camps Role model mentoring Outreach programs
Theme III	Performance and Gender Differences	<ul style="list-style-type: none"> Teacher support & gender Parental support & occupation Socioeconomic and cultural factors

Theme I: Attitudes towards Gender Differences in STEM School Education

Attitude is one of the important dimensions which needs to be studied to address the issue of under-

representation of women in STEM. The dimension of attitude can be approached from three main aspects, that is, from the perspectives of the students, teachers and educators, and parents.

Attitudes of Students: It is imperative to look at the perspectives, attitudes and beliefs of the students. It is because the attitude of the students has a direct bearing on their performance. Sarouphim and Chartouny (2017) conducted their study among secondary school students who were in seventh to ninth grades in four private schools in Lebanon. The authors have attempted to look into the gender differences in attitude towards mathematics and mathematics achievement among students. The Attitudes Toward Mathematics (ATM) scale was used for the study. In this study, it has been seen that there were no gender differences in mathematics achievement or attitude towards mathematics among the students. While this study mentioned that there were no gender differences in attitude towards science between male and female students, findings from other studies portray a different picture. For instance, Wan and Lee (2017), who have conducted a quantitative study among secondary school students in Hong Kong, have argued that male students have a more positive attitude towards science than female students. In this study, attitude towards science has been approached in terms of five dimensions-self-concept in science, enjoyment in science, learning science in and outside the classroom and future participation. Sáinz and López-Sáez (2010), who conducted their study among secondary school students in rural areas of Spain, have argued that female students have a lower positive computer attitude than male students. Some studies have also looked into the motivation of the students in STEM. For instance, Koul et al. (2023), who conducted their study among secondary students in Australia, have shown that girls are undermotivated about their STEM projects as compared to boys. In the context of Hong Kong, Oon et al. (2020) have shown that female students have a lesser liking towards physics than male students. Lee and Yuan (2010) have also shown that girls exhibit less enjoyment and pride and more anxiety, shame and hopelessness in the case of studying mathematics than boys. While the majority of the studies have talked about girls hav-

ing a negative attitude towards STEM, there are a few studies that have discussed the positive attitude of female students towards STEM. For instance, Aini et al. (2019), who conducted their study among primary and middle school students, have shown that female students have a more positive attitude towards science than male students. A similar picture has also been depicted by Liu et al. (2014) in the context of Chinese society among middle and high school students, where it has been seen that girls find science difficult and they believe that boys are more capable of doing science. In the context of Greece, Barkatsas et al. (2009) have argued that boys have a more positive attitude towards mathematics and the use of technology in learning mathematics as compared to girls. Niño-Cortés et al. (2023) who have conducted their study among the secondary education students in Spain have shown that boys report higher digital competence (DC) perception and attitude than girls. The authors have mentioned in their study that despite DC getting improved in both the genders over the course of time, the attitude of girls towards digital technology (DT) worsened and they had a poor DC self-perception by the time they reached upper secondary level. The study mentions that the lack of female role models, lack of recognition of equal career opportunities and associating the use of DT with social attributes of masculinity lead to a negative attitude of girls towards technology. While most of the studies have attempted to look into the gender differences in attitude with respect to one of the disciplines within STEM, Else-Quest et al. (2013), who have conducted their study among tenth grade students of public schools, have looked into the gender differences in science attitude and mathematics attitude. The study mentions that while male adolescents report greater math self-concept and expectations for success while female adolescents report greater science value. This study uses the theoretical framework of expectancy-value theory. While most of the studies have mentioned that boys have more positive attitude towards science, the study on Indonesia conducted by

Susilawati et al. (2022) among secondary school students have shown that girls have a more positive attitude towards science than boys. In the context of Sudan, Etim and Gindeel (2015), who have conducted a study on female students of secondary schools, have shown that girls have a high interest in mathematics and science and reported to achieve high scores in teacher made tests and assignments. Michael and Alsup (2016) have mentioned about lower attitude towards engineering and technology among female students due to lower self-esteem and lower engineering and technology identity in the context of the United States. Another study on middle school students in the United States by Ober et al. (2024) has argued that female and underrepresented minority (URM) students had a lower interest towards computer programming at the initial period. Kalali (2019), who has conducted the study among secondary school students in France has argued that despite most of the female students agreeing that science is an important discipline, they believe that science is not meant for them. Uitto (2014), who has carried out the study among upper secondary students in the context of Finland, has argued that the orientation of students towards science-related careers is influenced by social persuasions, self-efficacy beliefs and attitude towards science and mathematics and that girls are more oriented towards biology-related careers. Gok (2021), who conducted the study in Turkey among secondary school students, found that the attitude and motivation values toward STEM of the female students in metropolitan areas, according to grade levels, were lower than the STEM values of the male students.

Attitudes of Teachers and Educators: Sarouphim and Chartouny (2017), who have conducted their study in Lebanon, have also looked into the beliefs and perceptions of the teachers on the abilities of their students. For the purpose of the study, the teachers have been interviewed outside class hours. The authors showed that despite there being no differences between the attitudes and achievements of the female and male stu-

dents in mathematics, the teachers believed that mathematics was a masculine domain and they attributed the success of the boys to their abilities and the success of the girls to their efforts. In this study, the authors also mentioned how the beliefs and perceptions of the teachers also shaped their classroom interactions with their male and female students. Whether it was in the form of reprimands or in the form of one-on-one interaction, it was seen that the teachers used to have twice the interaction with the male students as compared to the female students. That there is a gendered interaction between teachers and female and male students has also been highlighted by Oon et al. (2020), who have conducted their study among secondary school students in Hong Kong. The female students who were part of the study reported that they received less recognition and attention from the physics teachers. Houtte (2025) investigated the impact of the sex composition of the school and the subject being taught on the difference in teacher-perceived boys' and girls' teachability.

Attitudes of Parents and Community: It is also important to take into consideration the beliefs and attitudes of the parents. Many studies have shown that the beliefs and attitudes of the parents shape the attitude of their children towards science. For instance, Wan and Lee (2017) and Chang et al. (2009) have argued that parents believe that science is more important for boys and that boys are more competent in doing science. Sáinz and López-Sáez (2010) have also shown that the occupation of the mother can also influence the computer attitude among boys. It has been seen that the boys whose mothers are employed outside the home have a more positive computer attitude than the boys whose mothers are unemployed.

Attitude towards STEM shapes the learning outcomes and achievement of the students. While most of the studies have shown that girls have a lower or negative attitude towards STEM as compared to boys, few studies have also pointed out that there is no gender difference between the STEM attitude of male and female students

or that girls have a positive or higher attitude towards STEM as compared to boys. Thus, it shows that attitude is not biologically determined. Attitude towards STEM is socio-culturally determined. It is interesting to note that most of the studies have talked about attitudes towards STEM among secondary school students. While middle school years are generally considered to be formative years among students, we have to keep in mind that gendered socialization starts right from the time a child is born. Thus, attitudes towards STEM start taking shape from childhood itself. Therefore, future research on STEM attitudes needs to be undertaken among children at the primary or elementary school level. It would help the policymakers to develop effective interventions to improve the attitude towards STEM among female students from a very early age.

Theme II: Interventions to attain gender equity in STEM School Education

Interventions are a necessary step to address the issue of the underrepresentation of women in STEM. There are different types of interventions. In this paper, the interventions have been categorized into two major types- pedagogical interventions and informal science learning interventions. In this review, around eighty-seven papers have been included that talk about interventions. The following paragraphs will discuss pedagogical and informal science interventions, respectively.

Pedagogical Interventions: From this review, it has been seen that more than half of the papers are talking about pedagogical interventions. The studies that are associated with pedagogical interventions can be further classified into three types: curriculum-based interventions, teacher training and project-based learning. From the reviewed articles, it can be seen that most of the pedagogical interventions are at the secondary school level. In their micro-video-based ethnographic study on secondary school students in the United States, the participation of male and female students in small group work in an integrated STEM curriculum-based intervention was examined by Wieselmann et al. (2021). In this

study, the authors have shown that participation in single-gender groups was better than mixed-gender groups because there was more cohesiveness and less conflict. Another study by Koul et al. (2023) on the participation in integrated STEM projects among secondary school students has argued that greater support for the girls through feedback on their tasks could have made the intervention more effective.

In the context of Saudi Arabia, Kim and Alghamdi (2019) have argued that the reform in the science curriculum was brought about. The teachers who were interviewed for the study welcomed the reform, and it was predicted that it would improve the performance of the girls and their scientific metacognitive learning orientation. Fung (2020), who carried out a study among eighth-grade students who participated in a teaching intervention on the use of electricity from two secondary schools in Hong Kong, has argued that effective group work can reduce the gender and social class differences in the science performance of students. The author further mentions that a gender-balanced and socioeconomically diverse arrangement was found to be an important element of social group work practice. A study in Finland by Nieminen et al. (2013) looked at a teaching intervention in the form of interactive engagement (IE) with the students at the upper secondary level. In this study, the authors have argued that both girls and boys benefited equally from the gender-neutral IE approach. However, the gender differences that were present prior to the teaching intervention could not be addressed. Kurbanoglu and Nefes (2016), who have conducted their study among the secondary students in Turkey, have shown that context-based questions, which are a form of teaching intervention, can reduce test anxiety and can improve the performance of the students. However, they did not find any statistically significant difference in terms of gender with respect to the intervention.

Another form of pedagogical intervention is group learning. Hossain and Tarmizi (2012), who conducted their study among secondary school students in the rural parts of Bangladesh, argued

that the fifteen-week intervention group learning in mathematics was highly effective. In this study, it has been seen that the girls benefitted more than the boys and also outperformed them. There is a socially prevalent notion that girls are not interested in the field of engineering. Benavides et al. (2023), who conducted their study among middle school students in the United States, have shown that girls can also develop an interest in engineering with the right type of curriculum-based intervention. The curriculum was based on using technology for making a sustainable community and was named 'Engineering for Sustainable Communities' (EfSC). The teachers had to undergo professional development before the curriculum was implemented. In this study, it has been seen that curricular intervention has helped the girls to bring forth their embodied form of knowledge to their engineering designs for the welfare of the community. As they chose engineering problems based on their personal experiences, it helped them to perceive themselves as an expert in the field of engineering. Liu et al. (2014), who conducted their study among high school students, have mentioned the importance of project-based learning in improving STEM self-efficacy among girls. In this study, the authors have shown that as the girls could work in proximity with the female role models in engineering, it helped them enhance their enthusiasm and confidence in engineering. Liccardo et al. (2025) conducted a study in schools of Naples (Italy) through a project-based learning approach and concluded that traditional gender roles and stereotypes persist.

Informal Science Learning Interventions: Besides, the other studies have discussed interventions that can broadly be categorized as informal science learning interventions in the form of science camps and science clubs, mentoring by role models, participation in competitions and such. Ayuso et al. (2020), who conducted their study in Spain among children from primary school, have mentioned an informal science learning intervention called 'A Female Engineer in Every School'. This initiative was initiated by a few fe-

male professors at a university in Spain in 2016. The professors realised that the initiatives taken by high school students to encourage students to take up engineering were ineffective because by the time students come to the high school level, they have already chosen their streams and study pathways. As part of the intervention, female engineers, both from academic and industry backgrounds, visit primary schools so that children can see them as role models. Open and interactive workshops are organized so that students can work in groups on some technology-related projects. This study, however, does not mention if the intervention was effective in developing an interest in engineering among girls. English et al. (2011) conducted their study among middle school students in Australia, where they mentioned the engineering education program, which was introduced to students of seventh, eighth and ninth grades. From this intervention, it was seen that despite equal opportunities, boys perceived themselves to be more successful in science subjects and showed more interest in learning science than girls. In the context of Spain, Merayo and Ayuso (2023) talk about the Ingenious Project that was initiated in 2019 to improve the participation of female students from secondary school levels in technological vocation.

Teacher training and dissemination of talks and experiments were part of the project. Riegle-Crumb et al. (2023), in their qualitative study, have attempted to understand the viewpoints of female high school students from different racial backgrounds who participated in an outreach program in engineering in the United States. From this study, it was seen that critical self-efficacy was mostly present among girls of colour and that Asian girls had it the least.

Some studies have also looked at the science camps. For instance, Levine et al. (2015) talked about an outreach chemistry camp that was organized for middle school girls in the United States in their study. The intervention was found to be successful because post-intervention, the girls seemed to be more motivated in pursuing a career in STEM. However, the long-term

effect of the intervention has not been looked at in this study. Another study from the United States by Weavers et al. (2011) on a free one-week engineering day camp for girls from middle school levels has shown that the camp helped in reinforcing the already present positive attitude and high aspirations towards mathematics and science within the girls. Todd and Zvoch (2017) have mentioned an outreach program for girls in science in the United States, which included hands-on activities, peer role models, peer learning and such within a summer camp. Post-intervention data collection showed that the middle school girls who participated in the outreach program reported higher science affinities as compared to their peer groups who did not. In another study, Todd and Zvoch (2019) also talked about a cohort-based science summer camp among middle school girls in the United States and mentioned that the camp gave them a space to fail and yet work through their failures through support and encouragement. Another study by Hughes et al. (2013) in the context of the United States has tried to understand if girls would perform better in single-sex science camps as compared to girls in mixed-gender summer camps. In this study, the authors have shown that the girls benefited equally from both the camps and their science identities were strengthened through the activities in the science camps.

Reznik et al. (2023) conducted their study among female students from elementary and high schools in a low-income setting in Brazil who participated in some science and mathematics projects organized by some universities and research institutes. In this study, the authors have argued that the inclusive spaces that the projects offered helped the students build interest and confidence and value their own skills. The authors have further argued that the projects became “counter spaces” for these female students coming from marginalized backgrounds, where they felt included. That counter structures and counter spaces could play an important role in developing STEM identity among girls coming from marginalised socio-economic backgrounds

has been reiterated in another study by Erete et al. (2021) in the context of the United States. In this study, the authors have discussed an out-of-school program, Digital Youth Divas (DYD), which was specifically designed for Latina girls and girls of colour. DYD is a community of peers and mentors which emphasises hands-on learning experiences and tries to engage girls in design-based engineering and computer science activities. The intervention was effective in developing STEM identity among female students. While most of the interventions were made at the level of middle schools, few interventions were also brought about at the primary school level. For instance, Caspi et al. (2023) have discussed an informal STEM programme that was designed for primary school children. In this study, the authors tried to understand the reasons why the students participated in specific programmes and their career aspirations. From the data that was collected it was seen that more boys participated in these programmes and that more boys from third and fourth grades aspired for a STEM career than girls. However, the study emphasizes that participation in such informal STEM programmes helps in STEM career entry from an early age by helping retain the students’ interests in STEM. In another study based in the United States, Kim (2016) argued that a one-week inquiry-based STEM program that was for girls at the middle school level was successful in increasing participants’ positive attitudes toward science, science-related careers, and content knowledge of selected science concepts. Stevenson et al. (2021), who have also conducted their study in the context of the United States, have shown in their study how an outdoor science education program which consisted of hands-on science investigation, science journaling, nature exploration and reflection, helped the girls to stay engaged with science by reducing the effect of culturally promoted disengagement with science. Barksdale et al. (2022) have argued that the informal learning program on computer science for middle school girls from the United States helped them develop an interest in computer science and computing

perspectives. Levine and DiScenza (2018) have also shown that a chemistry outreach program for middle school girls organized by a university in the United States was successful in improving the responses of the participants regarding the applicability of science and also in improving their interest in pursuing a career in science. While most of the studies have mentioned that the interventions undertaken were successful, Wade-Jaimes et al. (2022) have shown how the STEM club for African-American female students at the middle school level, which aimed to create an egalitarian space for them failed to make the students unlearn the discriminatory practices. The students perceived the STEM club activities as 'science-like' but not 'real science'.

From the review of the intervention-based studies, it can be argued that many informal science learning interventions have taken place in the Global North, especially in the United States. There is a lack of literature on interventions from the Global South.

Theme III: Performance and Gender Differences in STEM School Education

The existing scholarship on STEM has shown that there is a gender difference in STEM performance. Globally, there is a growing concern over this differential STEM performance among male students and female students because it is leading to the underrepresentation of women in STEM (Else-Quest et al., 2010; Liu et al., 2014).

There are multifarious factors that may influence performances in STEM disciplines. One of the factors is the gender of the instructor. Sullivan and Bers (2019), who conducted their study among elementary school children in the context of the United States among the economically disadvantaged sections of the society, have shown that a female instructor may positively impact the learning outcomes of girl children in robotics. Apart from the gender of the instructor or the teacher, the social support from the teacher also has a positive impact on the learning outcomes of the students. Ansong et al. (2020), who conducted their study among junior high school students in Ghana, have argued that support from

teachers is the most important predictor of STEM performance. In this study, the authors have tried to make a comparison between the performances of female and male students and students from urban and rural backgrounds. The authors have argued that boys and girls have equal capabilities to succeed in STEM subjects. However, the performance of the girls worsens over time due to the sociocultural context where girls are taught to view STEM careers predominantly as a masculine domain. Thus, negative attitudes, low confidence, motivation and interest in science lead to poor performance of girls in STEM (Khanyane et al., 2016). Awofala (2017), who conducted a study among senior secondary school students from higher socioeconomic backgrounds in Nigeria, has also argued that despite there being no significant gender differences in mathematics proficiency among boys and girls, there is a significant gender difference between boys and girls in terms of mathematics performance, where boys perform significantly better than girls. Heidari and Rajabi (2017), who conducted their study among the students of junior schools in Iran, have also shown that male students perform better than female students in mathematics.

Moreover, parental support and parental occupation are the other two factors that impact how female children and male children perform in the field of STEM education. For instance, Hoferichter and Raufelder (2019) conducted their study among eighth and ninth-grade students in a public secondary school in Germany to understand the relationship between parental support and their grades obtained in mathematics and biology. In this study, it has been seen that the performance of boys in mathematics is negatively associated with the support from their mothers. On the other hand, the achievements of the girls are positively benefited as a result of their maternal support.

Few studies have shown that there are different factors that affect the performance of male and female students differently. Khanyane et al. (2016), who conducted a qualitative study in secondary school settings in the African coun-

try Lesotho, have argued that using the English language negatively affects the comprehension of science, especially among boys. The study has also shown that in the case of girls, socioeconomic and cultural factors hinder the time that the girls could devote towards their studies.

While most studies have delved into the factors that negatively affect the performance of female students in STEM disciplines, few studies have also talked about girls outperforming boys in STEM. For instance, Onoshakpokaiye (2024), who conducted a study among secondary students in Nigeria, has shown that female students had high self-concept and high motivation, which led to better mathematics performance as compared to male students.

Much work has been conducted on STEM performance globally, especially in the Global North. However, there is a lack of literature that may have emerged on STEM performance at the school level from the Indian context. Jaiswal and Choudhuri (2017) conducted their study on secondary school students in the Indian context. The authors have shown how academic self-concept influences academic achievement among students and that there is a difference between the academic self-concept of male students and the academic self-concept of female students. However, this study considers academics in general, and it does not specifically talk about STEM performance.

RQ 3: What research gaps exist in current research on STEM school education and what are potential future research areas?

There is a dearth of studies on STEM education at the level of schools in the Global South, especially in the context of India. There is also a lack of literature on intervention, especially at the primary school level. There is thus a need to fill this gap through future research. It has also been seen that there is a lack of literature on performance from the Global South. Similarly, it has also been seen that attitude has been studied mostly among secondary school students.

Contextual and Regional Gaps

The Global South remains underrepresented in the current STEM education scholarship. There is a significant volume of work that has emerged from the Global North, research that captures socio-cultural specificities, regional disparities, and structural inequalities influencing girls' STEM engagement and outcomes in countries like India is sparse. Rural contexts are largely overlooked, despite the unique socio-cultural, infrastructural, and economic challenges that shape girls' access, participation, and success in STEM education. This limits the generalizability and applicability of findings across diverse geographies.

Existing studies predominantly focus on secondary school students, with little attention to the primary or elementary level, despite early childhood being a formative period for the development of science attitudes, identity, and aspirations. Interventions and attitudinal studies at the middle or high school level may be too late to respond to entrenched gendered socialization. There is an urgent need for longitudinal, early-intervention research to understand how gendered attitudes towards STEM evolve from childhood.

Theoretical and Intersectional Gaps

While psychological theories like social cognitive theory and expectancy-value theory have dominated existing studies, frameworks such as intersectionality, feminist theory, and social capital theory remain underutilized, particularly in performance and attitudinal studies. These lenses can offer richer insights into how multiple dimensions of identity (e.g., gender, class, caste, and ethnicity) shape students' STEM experiences. Intersectional analyses are especially lacking in studies from India and similar contexts, where gender often intersects with rural-urban, caste, religion, and socioeconomic status to influence STEM access and achievement.

Methodological Gaps

A large proportion of existing research uses quantitative methods, particularly surveys, to assess attitudes and performance. While these are use-

ful for breadth, they lack depth and contextual sensitivity. There is a need for qualitative, ethnographic, and longitudinal studies that unpack the nuanced experiences and identity formations of girls in STEM. Many studies fail to assess the long-term effectiveness of interventions, particularly informal STEM learning programs. Follow-up studies that measure sustained impacts on attitudes, self-efficacy, and STEM career trajectories are scarce.

Limitations

This thematic review has a few limitations that should be kept in view while interpreting the findings. First, this review was limited to research articles published in English, which may have led to the exclusion of relevant articles published in other languages. Second, the literature search for this review study was confined to a specific database, i.e. Scopus; therefore, it might have overlooked some studies indexed exclusively in other databases. Finally, the thematic analysis has been derived from the empirical studies in the context of STEM education at school levels, which limits the ability of this review to draw overarching conclusions beyond specific educational contexts.

Conclusion

Science and technology education is widely acknowledged as a pivotal driver of national progress and holistic development. The issue of gender disparity within STEM education has been a longstanding universal concern. Globally, women remain significantly underrepresented in STEM educational pursuits. There is a dearth of studies on STEM education at the level of schools in the Global South. There is also a lack of literature on intervention, especially at the primary school level. There is thus a need to fill this gap through future research. It has also been seen that there is a lack of literature on performance from the Global South. Similarly, it has also been seen that attitude has been studied mostly among secondary school students. The equitable inclusion of women in STEM domains is imperative not only for establishing a gender-equitable society but also for promoting female participation in the labour market.

Acknowledgement

This research paper is an outcome of a research project titled 'Gender parity in STEM education', sponsored by the Indian Council of Social Science Research (ICSSR), New Delhi. The author thanks the funding organisation for providing its generous support to conduct this research project. The author acknowledges her institute of affiliation, MNIT Jaipur, for the opportunity, research resources and administrative support in carrying out this research work.

References

1. Aini, R.Q., Rachmatullah, A., & Hu, M. (2019). Indonesian Primary School and Middle School Students' Attitudes toward Science: Focus on Gender and Academic Level. *Journal of Baltic Science Education, 18*(5), 654-667.
2. Ansong, D., Okumu, M., Albritton, T. J., Bahnuk, E.P., & Small, E. (2020). The role of social support and psychological well-being in STEM performance trends across gender and locality: Evidence from Ghana. *Child Indicators Research, 13*(5), 1655-1673. <https://doi.org/10.1007/s12187-019-09691-x>
3. Awofala, A.O. (2017). Assessing senior secondary school students' mathematical proficiency as related to gender and performance in mathematics in Nigeria. <https://doi.org/10.21890/ijres.327908>
4. Ayuso, N., Fillola, E., Masiá, B., Murillo, A.C., Trillo-Lado, R., Baldassarri, S. & Villarroya-Gaudó, M. (2020). Gender gap in STEM: A cross-sectional study of primary school students' self-perception and test anxiety in mathematics. *IEEE Transactions on Education, 64*(1), 40-49. <https://doi.org/10.1109/TE.2020.3004075>
5. Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice-Hall.
6. Barkatsas, A. (Tasos), Kasimatis, K., & Gialamas, V. (2009). Learning secondary mathematics with technology: Exploring the complex interrelationship between students' attitudes, engagement, gender and achievement. *Computers and Education, 52*(3), 562-570. <https://doi.org/10.1016/j.compedu.2008.11.001>
7. Barksdale, S., Scharber, C., & Chang, Y.H. (2022). Team Mensa: A case study of supporting middle school girls' interest in computer science through

- an informal learning program. *Journal of Research on Technology in Education*, 54(3), 359-374. <https://doi.org/10.1080/15391523.2020.1864239>
8. Benavides, A.W., Tan, E., & Calabrese Barton, A. (2023). We actually made something and solved a problem: Exploring relationships between middle school engineering culture and girls' engineering experiences. *Science Education*, 107(1), 149-179.
 9. Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77-101. <https://doi.org/10.1191/1478088706qp063oa>
 10. Buenestado-Fernández, M., Ibarra-Vazquez, G., Patiño, A., & Ramírez-Montoya, M.S. (2024). Stories about gender inequalities and influence factors: a science club case study. *International Journal of Science Education*, 46(5), 403-420.
 11. Caspi, A., Gorsky, P., Nitzani-Hendel, R., & Shildhouse, B. (2023). STEM-oriented primary school children: participation in informal STEM programmes and career aspirations. *International Journal of Science Education*, 45(11), 923-945. <https://doi.org/10.1080/09500693.2023.2177977>
 12. Chiang, F.K., Tang, Z., Zhu, D., & Bao, X. (2024). Gender disparity in STEM education: a survey research on girl participants in World Robot Olympiad. *International Journal of Technology and Design Education*, 34(2), 629-646.
 13. Else-Quest, N.M., Hyde, J.S., & Linn, M.C. (2010). Cross-national patterns of gender differences in mathematics: a meta-analysis. *Psychological bulletin*, 136(1), 103. <https://doi.org/10.1037/a0018053>
 14. Else-Quest, N.M., Mineo, C.C., & Higgins, A. (2013). Math and science attitudes and achievement at the intersection of gender and ethnicity. *Psychology of Women Quarterly*, 37(3), 293-309. <https://doi.org/10.1177/0361684313480694>
 15. English, L.D., Hudson, P., & Dawes, L. (2011). Perceived gender differences in STEM learning in the middle school. *International Journal of Engineering Education*, 27(2), 389-398.
 16. Erete, S., Thomas, K., Nacu, D., Dickinson, J., Thompson, N., & Pinkard, N. (2021). Applying a transformative justice approach to encourage the participation of Black and Latina Girls in computing. *ACM Transactions on Computing Education (TOCE)*, 21(4), 1-24. <https://doi.org/10.1145/3451345>
 17. Ergün, A. (2019). Identification of the interest of Turkish middle-school students in STEM careers: Gender and grade level differences. *Journal of Baltic Science Education*, 18(1), 90-104.
 18. Etim, J.S. & Gindeel, R. (2015). Female students' attitudes to and achievement in mathematics and science in selected secondary schools in Omdurman, Sudan. *International Journal of Education Economics and Development*, 6(4), 331-342. <https://doi.org/10.1504/IJEED.2015.075795>
 19. Fung, D. (2020). The impacts of effective group work on social and gender differences in Hong Kong science classrooms. *International Journal of Science Education*, 42(3), 372-405.
 20. Gok, T. (2021). The development of the stem (Science, technology, engineering, and mathematics) attitude and motivation survey towards secondary school students. *International Journal of Cognitive Research in Science, Engineering and Education*, 9(1), 105-119. <https://doi.org/10.23947/2334-8496-2021-9-1-105-119>
 21. Gudyanga, A., Mandizvidza, V., & Gudyanga, E. (2016). Participation of rural Zimbabwean female students in mathematics: The influence of perception. *Cogent Education*, 3(1). <https://doi.org/10.1080/2331186X.2016.1156836>
 22. He, L., Zhou, G., Salinitri, G., & Xu, L. (2020). Female Underrepresentation in STEM Subjects: An Exploratory Study of Female High School Students in China. *EURASIA Journal of Mathematics, Science and Technology Education*, 16(1).
 23. Heidari, R., & Rajabi, F. (2017). An investigation of the relationship between mathematics performance of students in a non-routine problem, according to grade and gender. *International Journal of Innovation in Science and Mathematics Education*, 25(3).
 24. Hoferichter, F., & Raufelder, D. (2019). Mothers and fathers—Who matters for STEM performance? Gender-specific associations between STEM performance, parental pressure, and support during adolescence. In *Frontiers in Education* (Vol. 4, p. 14). Frontiers Media SA. <https://doi.org/10.3389/educ.2019.0014>
 25. Høgheim, S., & Reber, R. (2019). Interesting, but Less Interested: Gender Differences and Similarities in Mathematics Interest. *Scandinavian Journal of Educational Research*, 63(2), 285-299. <https://doi.org/10.1080/00313831.2017.1336482>

26. Hong, C.N.T., Thu, H.L.T., Huy, V.N., & Le Thi, B. (2024). A systematic review of research on gender diversity in STEM education. *International Journal of Learning, Teaching and Educational Research*, 23(4), 217-233. <https://doi.org/10.26803/ijlter.23.4.12>
27. Hossain, M.A., & Tarmizi, R.A. (2012). Gender-Related Effects of Group Learning on Mathematics Achievement among the Rural Secondary Students. *Eurasian Journal of Educational Research*, 47, 1-22.
28. Houtte, Van M. (2025). School's sex-composition, teachers' accuracy and gender stereotypes: explanations for teachers' different teachability perceptions of boys and girls. *Soc Psychol Educ* 28, 81. <https://doi.org/10.1007/s11218-025-10044-6>
29. Hsieh, H.C., Chen, P.Y., & Lin, T. S. (2017). Girls' and Boys' Science Choices and Learning in Upper-Secondary Schools in Taiwan. *Asian Women*, 33(3), 41-64.
30. Hughes, R.M., Nzekwe, B., & Molyneaux, K.J. (2013). The single sex debate for girls in science: A comparison between two informal science programs on middle school students' STEM identity formation. *Research in Science Education*, 43, <https://doi.org/10.1007/s11165-012-9345-7>
31. Jaiswal, S.K., & Choudhuri, R. (2017). Academic self concept and academic achievement of secondary school students. *American Journal of Educational Research*, 5(10), 1108-1113. <https://doi.org/10.12691/education-5-10-13>
32. Jalak, J., & Nasri, N. (2019). Systematic review: The impact of pedagogy on equity in science education in rural schools. *Creative Education*, 10(12), 3243-3254. <https://doi.org/10.4236/ce.2019.1012248>
33. Kalali, F. (2019). Important but not for me as a girl: French students' attitudes towards secondary school science. *Review of Science, Mathematics and ICT Education*, 13(2), 61-79. <https://doi.org/10.26220/rev.3154>
34. Khanyane, M., Mokuku, T., & Nthathakane, M.C. (2016). Perceived gender differences in performance in science: the case of Lesotho secondary schools. *African Journal of Research in Mathematics, Science and Technology Education*, 20(3), 278-288. <http://dx.doi.org/10.1080/18117295.2016.1228826>
35. Kim, H. (2016). Inquiry-based science and technology enrichment program for middle school-aged female students. *Journal of Science Education and Technology*, 25, 174-186. <https://doi.org/10.1007/s10956-015-9584-2>
36. Houtte, M. Van. (2025). School's sex-composition, teachers' accuracy and gender stereotypes_ explanations for teachers' different teachability perceptions of boys and girls. *Social Psychology of Education*, 28.
37. Kim, S.Y., & Hamdan Alghamdi, A.K. (2019). Female Secondary Students' and Their Teachers' Perceptions of Science Learning Environments Within the Context of Science Education Reform in Saudi Arabia. *International Journal of Science and Mathematics Education*, 17(8), 1475-1496. <https://doi.org/10.1007/s10763-018-09946-z>
38. Koul, R.B., McLure, F.I., & Fraser, B.J. (2023). Gender differences in classroom emotional climate and attitudes among students undertaking integrated STEM projects: A Rasch analysis. *Research in Science & Technological Education*, 41(3), 1051-1071.
39. Kube, D., Weidlich, J., Jivet, I., et al. (2022). "Gendered differences versus doing gender": A systematic review on the role of gender in CSCL. *Unterrichtswissenschaft*, 50, 661-688. <https://doi.org/10.1007/s42010-022-00153-y>
40. Kurbanoglu, N.I., & Nefes, F.K. (2016). Context-Based Questions in Science Education: Their Effects on Test Anxiety and Science Achievement in Relation to the Gender of Secondary School Students. *Journal of Baltic Science Education*, 15(3), 382-390.
41. Lee, C.Y., & Yuan, Y. (2010). Gender Differences in the Relationship Between Taiwanese Adolescents' mathematics Attitudes and Their Perceptions Toward Virtual Manipulatives. *International Journal of Science and Mathematics Education*, 8, 937-950.
42. Levine, M., & DiScenza, D.J. (2018). Sweet science: Addressing the gender gap in STEM disciplines through a one-day high school program in sugar chemistry. *Journal of Chemical Education*, 95(8), 1316-1322. <https://doi.org/10.1021/acs.jchemed.7b00900>
43. Levine, M., Serio, N., Radaram, B., Chaudhuri, S., & Talbert, W. (2015). Addressing the STEM gender gap by designing and implementing an educational outreach chemistry camp for middle school girls. *Journal of Chemical Education*, 92(10), 1639-1644. <https://doi.org/10.1021/ed500945g>
44. Liang, M., Lim, C.P., Park, J., & Mendoza, N. (2022). A review of ICT-enabled learning for schoolgirls

- in Asia and its impacts on education equity. *Educational Technology Research and Development*, 71, 1-27. <https://doi.org/10.1007/s11423-022-10178-w>
45. Liccardo, A., Gargano, A., & Pastena, A. (2025). The Gender of Science: A Scientific Analytically-Based Project to Enhance Secondary School Students' Awareness of Gender Stereotypes in STEM. *Education Sciences*, 15(3), 270. <https://doi.org/10.3390/educsci15030270>
46. Liu, Y. H., Lou, S.J., & Shih, R.C. (2014). The investigation of STEM self-efficacy and professional commitment to engineering among female high school students. *South African Journal of Education*, 34(2), 1-15.
47. Merayo, N., & Ayuso, A. (2023). Analysis of barriers, supports and gender gap in the choice of STEM studies in secondary education. *International Journal of Technology and Design Education*, 33(4), 1471-1498. <https://doi.org/10.1007/s10798-022-09776-9>
48. Mérida-Serrano, R., González-Alfaya, M.E., Olivares-García, M.A., Rodríguez-Carrillo, J., & Muñoz-Moya, M. (2020). Sustainable development goals in early childhood education. Empowering young girls to bridge the gender gap in science. *Sustainability*, 12(22), 9312.
49. Michael, K.Y., & Alsup, P.R. (2016). Differences Between the Sexes Among Protestant Christian Middle School Students and their Attitudes Toward Science, Technology, Engineering and Math (STEM). *Journal of Research on Christian Education*, 25(2), 147-168. <https://doi.org/10.1080/10656219.2016.1191396>
50. Msambwa, M.M., Daniel, K., Lianyu, C., & Fute, A. (2023). A systematic review of the factors affecting girls' participation in science, technology, engineering, and mathematics subjects. *Computer Applications in Engineering Education*, 32, e22707. <https://doi.org/10.1002/cae.22707>
51. Nieminen, P., Savinainen, A., & Viiri, J. (2013). Gender differences in learning of the concept of force, representational consistency, and scientific reasoning. *International journal of science and mathematics education*, 11, 1137-1156.
52. Niño-Cortés, L.M., Grimalt-Álvaro, C., Lores-Gómez, B., & Usart, M. (2023). The digital gender gap in secondary school: differences in self-perceived competence and attitude towards technology. *Educación XX1*, 26(2), 299-322.
53. Ober, T.M., Cheng, Y., Coggins, M.R., Brenner, P., Zdankus, J., Gonsalves, P., Johnson, E., & Urdan, T. (2024). Charting a path for growth in middle school students' attitudes toward computer programming. *Computer Science Education*, 34(1), 4-36. <https://doi.org/10.1080/08993408.2022.2134677>
54. Onoshakpokaiye, O.E. (2024). Students' psychological variables connection with secondary school students' academic performance in mathematics. *Arab Gulf Journal of Scientific Research*.
55. Oon, P.T., Cheng, M.M.W., & Wong, A.S.L. (2020). Gender differences in attitude towards science: methodology for prioritising contributing factors. *International Journal of Science Education*, 42(1), 89-112. <https://doi.org/10.1080/09500693.2019.1701217>
56. Patall, E.A., Steingut, R.R., Freeman, J.L., Pituch, K.A., & Vasquez, A.C. (2018). Gender disparities in students' motivational experiences in high school science classrooms. *Science Education*, 102(5), 951-977.
57. Patrick, H., Mantzicopoulos, P., & Samarapungavan, A. (2009). Motivation for learning science in kindergarten: Is there a gender gap and does integrated inquiry and literacy instruction make a difference. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, 46(2), 166-191.
58. Prieto-Rodríguez, E., Sincock, K., & Blackmore, K. (2020). STEM initiatives matter: Results from a systematic review of secondary school interventions for girls. *International Journal of Science Education*, 42(7), 1144-1161. <https://doi.org/10.1080/09500693.2020.1749909>
59. Reznik, G., Massarani, L., & Calabrese Barton, A. (2023). Informal science learning experiences for gender equity, inclusion and belonging in STEM through a feminist intersectional lens. *Cultural Studies of Science Education*, 18(3), 959-984. <https://doi.org/10.1007/s11422-023-10149-4>
60. Riegle-Crumb, C., Russo-Tait, T., Doerr, K., & Nguyen, U. (2023). Critical consciousness of gender inequality: Considering the viewpoints of racially diverse high school girls with engineering aspirations. *Sociological Perspectives*, 66(1), 5-27. <https://doi.org/10.1177/07311214221112448>
61. Roue, Leah C. (2014). Gender-based differences in school-aged Children's divergent thinking. *Inter-*

- national Journal of Cognitive Research in Science, Engineering and Education*, 2(2), 1-6.
62. Rowan, L., & Lynch, J. (2011). The continued underrepresentation of girls in post-compulsory information technology courses: A direct challenge to teacher education. *Asia-Pacific Journal of Teacher Education*, 39(2), 83-95.
 63. Sahoo, S., & Klasen, S. (2021). Gender segregation in education: evidence from higher secondary stream choice in India. *Demography*, 58(3), 987-1010.
 64. Sáinz, M., & López-Sáez, M. (2010). Gender differences in computer attitudes and the choice of technology-related occupations in a sample of secondary students in Spain. *Computers & Education*, 54(2), 578-587. <https://doi.org/10.1016/j.compedu.2009.09.007>
 65. Sarouphim, K.M., & Chartouny, M. (2017). Mathematics education in Lebanon: Gender differences in attitudes and achievement. *Educational studies in mathematics*, 94, 55-68. <https://doi.org/10.1007/s10649-016-9712-9>
 66. Simpkins, S.D., Price, C.D., & Garcia, K. (2015). Parental support and high school students' motivation in biology, chemistry, and physics: Understanding differences among Latino and Caucasian boys and girls. *Journal of Research in Science Teaching*, 52(10), 1386-1407.
 67. Šimunović, M., & Babarović, T. (2020). The role of parents' beliefs in students' motivation, achievement, and choices in the STEM domain: A review and directions for future research. *Social Psychology of Education*, 23, 701-719. <https://doi.org/10.1007/s11218-020-09555-1>
 68. Stevenson, K.T., Szczytko, R.E., Carrier, S.J., & Peterson, M.N. (2021). How outdoor science education can help girls stay engaged with science. *International Journal of Science Education*, 43(7), 1090-1111. <https://doi.org/10.1080/09500693.2021.1900948>
 69. Sullivan, A., & Bers, M.U. (2019). Investigating the use of robotics to increase girls' interest in engineering during early elementary school. *International Journal of Technology and Design Education*, 29(5), 1033-1051. <https://doi.org/10.1007/s10798-018-9483-y>
 70. Susilawati, Aznam, N., & Paidi. (2022). Attitudes Towards Science: A Study of Gender Differences and Grade Level. *European Journal of Educational Research*, 11(2), 599-608. <https://doi.org/10.12973/eu-jer.11.2.599>
 71. Todd, B., & Zvoch, K. (2017). Exploring girls' science affinities through an informal science education. *Research in Science Education*. 54. <https://doi.org/10.1007/s11165-017-9670-y>RISE-D-16-00206.2
 72. Todd, B., & Zvoch, K. (2019). The effect of an informal science intervention on middle school girls' science affinities. *International Journal of Science Education*, 41(1), 102-122. <https://doi.org/10.1080/09500693.2018.1534022>
 73. Tomassini, C. (2021). Gender gaps in science: Systematic review of the main explanations and the research agenda. *Education in the Knowledge Society (EKS)*, 22, <https://doi.org/10.14201/eks.25437>
 74. Uitto, A. (2014). Interest, attitudes and self-efficacy beliefs explaining upper-secondary school students' orientation towards biology-related careers. *International Journal of Science and Mathematics Education*, 12(6), 1425-1444. <https://doi.org/10.1007/s10763-014-9516-2>
 75. Wade-Jaimes, K., King, N.S., & Schwartz, R. (2021). "You could like science and not be a science person": Black girls' negotiation of space and identity in science. *Science Education*, 105(5), 855-879. <https://doi.org/10.1002/sc.21664>
 76. Wade-Jaimes, K., Cohen, J.D., & Calandra, B. (2022). A cultural historical comparison of in-school and out-of-school STEM activity systems for African-American girls. *Cultural Studies of Science Education*, 17(2), 511-540. <https://doi.org/10.1007/s11422-021-10070-8>
 77. Wan, Z.H., & Lee, J.C.K. (2017). Hong Kong secondary school students' attitudes towards science: A study of structural models and gender differences. *International Journal of Science Education*, 39(5), 507-527. <http://dx.doi.org/10.1080/09500693.2017.1292015>
 78. Wang, N., Tan, A.L., Zhou, X., Liu, K., Zeng, F., & Xiang, J. (2023). Gender differences in high school students' interest in STEM careers: A multi-group comparison based on structural equation model. *International Journal of STEM Education*, 10(1), 59.
 79. Weavers, L.K., Bautista, D.T., Williams, M.E., Moses, M.D., Marron, C.A., & La Rue, G.P. (2011). Assessing an engineering day camp for middle-school girls. *Journal of Professional Issues in Engineering*

- Education and Practice*, 137(3), 127-134. [https://doi.org/10.1061/\(ASCE\)EI.1943-5541.0000046](https://doi.org/10.1061/(ASCE)EI.1943-5541.0000046)
80. Wieselmann, J.R., Dare, E.A., Roehrig, G.H., & Ring-Whalen, E.A. (2021). "There are other ways to help besides using the stuff": Using activity theory to understand dynamic student participation in small group science, technology, engineering, and mathematics activities. *Journal of Research in Science Teaching*, 58(9), 1281-1319.
81. Yabas, D., Kurutas, B.S., & Corlu, M.S. (2022). Empowering girls in STEM: Impact of the girls meet science project. *School Science and Mathematics*, 122(5), 247-258.
82. Yu, W., He, J., Luo, J., & Shu, X. (2024). Interventions for gender equality in STEM education: A meta-analysis. *Journal of Computer Assisted Learning*, 40(6), 2558-2573. <https://doi.org/10.1111/jcal.12928>
83. Zhang, F., & Bae, C.L. (2020). Motivational factors that influence student science achievement: A systematic literature review of TIMSS studies. *International Journal of Science Education*, 42(17), 2921-2944. <https://doi.org/10.1080/09500693.2020.1843083>
84. Zhang, H., Cheng, X., & Cui, L. (2021). Progress or stagnation: Academic assessments for sustainable education in rural China. *Sustainability (Switzerland)*, 13(6). <https://doi.org/10.3390/su13063248>