Gender disparities and potentials in STEM approach in Jordan and Saudi Arabia – An analytical literature review

JEHAN ALGHNEIMIN¹*, ATTILA VARGA² and MONIKA KOVACS³

¹ Doctoral School of Education, ELTE Eötvös Loránd University, Budapest, Hungary
² Institute of People–Environment Transaction, ELTE Eötvös Loránd University, Budapest, Hungary
³ Institute of Intercultural Psychology and Education, ELTE Eötvös Loránd University, Budapest, Hungary

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ABSTRACT

In recent years, the integrated approach of STEM disciplines (Science, Technology, Engineering, and Mathematics) has been adopted in the Middle East to improve students’ scientific capacities and their formative thinking. Nevertheless, this approach encounters complications in the application, including many due to gender differences. Middle Eastern women’s life and education is affected by conservative constraints and social norms where gender stereotypes and culture impact shared views about specific domains. Research regarding gender has frequently emphasized gender imbalance in virtually all STEM study fields and professions. This study explores STEM education’s conceptual framework in Jordan and Saudi Arabia. Likewise, it provides an overview of STEM teachers’ practices and their gender perspectives in the classrooms. We investigate the implementations and gender differences in STEM education by scrutinizing relevant literature and studies in the selected countries. The conclusions indicate a shortage of teachers’ knowledge in applying STEM education in classrooms and a need for more development programs that qualify teachers for STEM education applications. In addition, the results show that gender disparities are promoted by the education system and teachers who teach STEM subjects in schools because social norms and gender stereotypes influence them.

* Corresponding author. E-mail: jhan@student.elte.hu
INTRODUCTION

In recent decades, researchers have progressively noted the significance of science, technology, engineering, and math education (STEM) in the classroom (Kennedy & Odell, 2014; Hobbs, Clark, & Plant, 2018). Moreover, with the technological explosion and the growing fears about the global economy, students need educational opportunities that help them keep up with the rapidly changing society. This need has brought a new scope to merge education systems with the economy’s needs and demands. Thus, educators must use project-based approaches focusing on STEM skills and methods to keep the market and education on the same development track (Arabian Business Consultants for Development, 2017; Brown, Brown, Reardon, & Merrill, 2011; Stohlmann, Moore, & Roehrig, 2012).

STEM is an approach that involves integrated learning to meet global demands for new competencies in a technological era. However, traditional didactic teaching methods, such as face-to-face classroom teaching, remain dominant in undergraduate STEM fields worldwide (Brown et al., 2011). According to Suprapto (2016), the STEM approach emerged in the late 2000s and included formal and non-formal education programs from preschool to the tertiary level. In addition, governments have used the STEM approach to address a range of local, national, and global issues. Quintana-Cifuentes et al. (2020) and UNESCO (2015) also support this perspective, asserting that the quality of science and technology education is essential to socially and environmentally sustainable development.

In the Middle East, governments’ policies to access education, resources, and technologies have oriented teachers and students towards the STEM approach to developing scientific and critical thinking skills (Islam, 2019). Focusing on Saudi Arabia and Jordan, we find that Saudi Arabia is aware of the benefits of the STEM approach for the state’s social and financial growth. Therefore, plenty of effort has been put into applying policies that improve educational progress. However, the system needs to focus more on actions (Almazroa & Alshamrani, 2015; Madani, 2020). Likewise, in Jordan, the Ministry of Education realized the need to establish an educational scope that focuses more on creative thinking curricula, goes hand in hand with the nation’s economic needs, and fulfills the market demand (Abueita, Fayez, Alsabeelah, & Humaidat, 2022).

Gender should not be neglected in educational research related to STEM. Many gender disparities have been reported in STEM education; for instance, UNESCO (2017) reported that less than 35% of students who pursued STEM degrees at the higher education level worldwide were women. However, results are increasingly heterogeneous concerning the linkage between gender and participation rates (Sagala, Umam, Thahir, Saregar, & Wardani, 2019). Hammond, Matulevich, Beegle, and Kumaraswamy (2020) reported to the World Bank that there is no difference in test scores or enrollment levels between girls and boys, although sometimes girls’ performance is higher than that of boys on these tests. For example, girls in Jordan and Saudi Arabia score higher than boys on mathematics and science tests. PISA 2018 reported that in Jordan, there is no difference between boys’ and girls’ performance in mathematics, while girls...
perform higher than boys in science. Considering that among the high attainment in mathematics and science for boys and girls, 1 in 4 male students expected to work in STEM occupations at 30, while 1 in 9 girls expected to do so. Even though research consistently emphasizes females’ underrepresentation in virtually all STEM studies and careers globally, little is known about females in STEM education in Jordan and Saudi Arabia. STEM gender-related issues can be observed in these countries. Although Saudi Arabia has a literacy rate among the population aged 15 years and older of 95%, whereas female literacy is estimated to be at 92% and male literacy at 97% (UNESCO, 2017), women make up only 16% of the Saudi workforce, which is the lowest rate among the 20 countries included in the Global Gender Gap report (2020), followed by UAE with 20% and India with 22%.

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There may be several reasons why women are grossly underrepresented in STEM studies and STEM occupations (Darling-Hammond, Flook, Cook-Harvey, Barron, & Osher, 2020; Kricorian, Seu, Lopez, Ureta, & Equils, 2020). UNESCO (2017) exposed four types of factors that affect girls and women’s participation, advancement, and accomplishments in STEM education.

1. society factors, e.g., cultural norms, gender equality, etc.;
2. school factors, e.g., teachers’ perceptions, number of female teachers, STEM equipment and tools, pedagogy;
3. family and peer factors, e.g., parental beliefs, peer relationships, family characteristics, etc.; and
4. Learner factors, e.g., personal interest and motivation, stereotypes and STEM identities, self-perceptions and efficacy, etc.

This paper investigates the research concerning STEM education in Jordan and Saudi Arabia. Even though research consistently emphasizes females’ underrepresentation in virtually all STEM studies and careers globally, little is known about females in STEM education in these two nations. This study attempts to highlight issues that hinder the STEM approach and advance the research by synthesizing the literature on STEM education applications and the gender perspectives of teachers. The study attempts to answer the following questions:

1. How is STEM education conceptualized in the literature in the selected countries (Jordan and Saudi Arabia)?
2. What problems face the STEM approach in the Jordanian and Saudi contexts?
3. What gender perspectives do teachers have about STEM teaching?
STEM APPROACH

STEM education is a vital academic approach (Murphy, MacDonald, Danaia, & Wang, 2019) based on integrating educational concepts and practices in science and mathematics with concepts of technology and engineering by removing traditional barriers between the four disciplines and combining them into one coherent paradigm to form and create new knowledge (Thibaut et al., 2018). The term STEM comes from the initials of the words “science,” “technology,” “engineering,” and “mathematics.” Each of these disciplines is concerned with a specific aspect, as follows (Mutakinati, Anwari, & Kumano, 2018):

- **Science:** This discipline focuses on understanding basic facts, concepts, principles, laws, and theories. It involves bringing ideas, practices, skills, processes, scientific thinking, and creative methods together to develop knowledge and solve problems.
- **Technology:** This discipline focuses on managing, understanding, evaluating, and developing technology. It involves building models and designs; possessing the necessary skills to analyze how to use technology to develop and improve lives; and presenting ideas and developments in practical, engaging, and fruitful ways.
- **Engineering:** This discipline focuses on solving problems and achieving goals by applying the engineering design process. It involves describing and analyzing data and building models within its applications, including analytical principles and predictive skills. It can be seen as a method for designing objects, processes, and systems to meet life’s concrete needs, desires, and requirements (Ugras, 2018).
- **Mathematics:** This discipline focuses on identifying and understanding mathematics’s roles in our daily practices and gives meaning through its use in arithmetic, evaluation, and measurement operations.

The STEM initiative first appeared in the United States and focused on problem-solving and inquiry strategies for real-life issues. It aimed to link education to daily life applications to provide the learner with concepts and skills available from various fields of study (Brown et al., 2011). This approach emphasizes the integration of science, technology, engineering, and mathematics content and skills through standards associated with activities that increase student creativity in the four subject areas (Widayanti & Suyatna, 2019).

STEM education stresses the importance of posing a problem or challenge requiring students to work in collaborative teams to complete specific tasks, search for information from reliable sources to deepen knowledge and understanding and find connections between disciplines (Kanadli, 2019). This academic approach requires students to analyze and classify information, present hypotheses to design and propose models for experiments, and determine the necessary materials and tools to apply the suggested ideas and solutions to solve problems (Marshall & Harron, 2018). According to the STEM approach, the general goal of learning is to link scientific knowledge to life or reality. However, there are many other sub-goals, such as increasing students’ cognitive curiosity towards discovery and investigation and raising students’ confidence in scientific concepts by applying and employing them to explain phenomena and solve problems in various life settings (Leshner & Scherer, 2018). Furthermore, this approach aims to provide students with twenty-first-century skills via broad support for learning and knowledge transfer through integrated curricula. These curricula support students as they encounter everyday
challenges, developing their skills to use data in producing knowledge and enhancing their scientific vision to comply with global standards (Havice, Havice, Waugaman, & Walker, 2018).

STEM has several advantages, which can be categorized as follows (Lai, 2018):

- **Creativity development**: STEM education encourages creative thinking. Individuals or students are trained to think outside the box using their different skills and competencies.
- **Enhancing self-confidence**: STEM education allows students to participate in authentic learning experiences and express their ideas.
- **Problem-solving**: STEM education enables students to use scientific and creative models to solve local or global concerns (Allen & Peterman, 2019).
- **Enhancing participation**: STEM education encourages students to work in groups or within teams to solve a specific issue or to undertake a project or a design. It helps them build responsibility, accept others, develop critical thinking, and acquire life skills.

As noted in the previous definitions, STEM education is an approach that integrates four subjects: science, technology, engineering, and mathematics. It links them to the learner’s natural world and life situations by focusing on contexts that enhance discovery and improve students’ understanding of the areas of learning around them. Furthermore, it enables them to build a conceptual mathematical framework by linking it to practical life.

**METHODOLOGY**

This study explores the conceptual framework of STEM education and gives an overview of STEM teachers’ practices and gender perspectives in the context of Jordan and Saudi Arabia schools. We utilized ERIC, Semantic Scholar, and Science Direct databases to search for articles on STEM education, STEM Implementation for Schools, Integrating Science in the Context of Education, and STEM education awareness in Jordan and Saudi Arabia. We used an extended set of keywords to explore the literature, specifically “STEM education,” “mindset,” “Jordan,” “Saudi Arabia,” “implementation,” “interdisciplinary,” “gender stereotypes,” and “integration” as well as their extensions, such as “teachers’ mindsets,” “actual implementation of STEM education,” “STEM teachers in Saudi schools,” and “the integration of STEM.” “STEM education in Jordan” and “Gender stereotypes and science,” along with conference papers and reports by International agencies such as UNESCO and the World Health Organization. Our search included \( n = 67 \) documents (41 studies, nine reports, 17 systematic and literature reviews) written in English and peer-reviewed from 2000 to 2022 since the STEM approach emerged in the 2000s (Suprapto, 2016). We included studies about STEM application in the classrooms and gender perspectives in STEM from all over the globe. The authors selected the following eligibility standards: a) A study published from 2000 to 2022. b) Published in the English language; (c) Peer-reviewed except reports from International organizations such as UNESCO, (d) Focused on school/university students/teachers. The authors rated every study based on a set of criteria. They used a scale to determine whether each criterion was met until they reached a unanimous of 100%.
FINDINGS

STEM education in Saudi Arabia

In recent decades, Saudi Arabia has paid significant attention to education due to its impact on financial and social growth (Almazroa & Alshamrani, 2015). Therefore, science and mathematics curricula have gained vast interest from officials and decision-makers, who have emphasized the need to adopt new curricula that target students’ scientific abilities (Allmnakrah & Evers, 2019; Madani, 2020). However, the research shows different perspectives regarding the implementation of STEM education in Saudi Arabia. For instance, El-Deghaidy and Mansour (2015) found that teachers are unprepared to apply STEM education in Saudi middle schools. Another study by Widya et al. (2019) offers more insight into the insecurity towards applying STEM education in Saudi schools, stressing that teachers are unprepared and lack the literacy and inventive thinking necessary to apply the STEM approach. In addition, it highlights the importance of providing training and improving skills to guarantee better results. Likewise, Madani (2020) emphasized that teachers in Saudi schools lack teaching strategies to adequately apply STEM education practices. Bojulaia and Pleasants (2021) reported that teachers expressed dissatisfaction with STEM education practices and performance. Such results suggest a need for additional assets from the Saudi Ministry of Education to support STEM education practices in classrooms.

According to a study by Aldahmash, Naem, and Aljallal (2019), professional development programs reduce the difficulties of applying the STEM approach in the classroom. In addition, these programs promote the acquisition of critical thinking skills. Mousa and Kalonde (2019) point out a glimmer of hope toward understanding STEM education, suggesting a need for additional development programs and workshops that deeply concern STEM education strategies. Likewise, Smith, Lancaster, and Johnson (2019) recommend providing teachers with training in STEM education. This suggestion followed a sampling of 25 STEM educators in Saudi schools who displayed limited or naive understandings of STEM education. However, after 44 weeks in a training program, the educators improved their skills and thinking. In addition, some researchers suggest that teachers and students use STEM education tools of learning, such as the mobile learning model, to improve efficacy and performance (Mutambara & Bayaga, 2021).

The dilemma in applying STEM education in Saudi Arabia can be attributed to a lack of training programs that offer sufficient information and knowledge. In addition, teachers lack strategies for optimal STEM education in theory and application. Nevertheless, teachers and students show potential and acceptance of STEM interactive learning tools like the mobile learning model.

STEM education in Jordan

In Jordan, the Ministry of Education issued a series of objectives focused on developing the education system towards creative thinking and broadening skills obtained by students. Therefore, significant efforts have been made to employ computers in education and curricula (Abueita et al., 2022). These actions resulted from an analysis of educational outcomes in Jordan, which found that education was isolated from the economy and lacked real-life applications. Arabian Business Consultants for Development (2017) has reported similar results.
Nevertheless, the question, “Can the STEM approach contribute to developing the required scientific skills to improve the economy?” will be answered in this study by gathering different perspectives from the Jordanian context concerning STEM education.

Some studies have shown that the STEM approach could be more effective in Jordan’s practice and strategies. Alkhateeb (2018) studied mathematics teachers in Jordan who had felt inconvenienced by and dissatisfied with the STEM approach. He stressed that STEM education requires more qualified teachers with confidence and comfort towards such an approach. Furthermore, his results showed that teacher development programs had yet to hit the target objectives for STEM. Others, such as Bedar and Al-Shboul (2020), highlighted students’ need for more motivation towards the STEM approach and emphasized that development programs must help teachers offer more variety in STEM practices and classroom strategies to maintain students’ motivation to learn. Qablan (2021) stated that STEM education in Jordan faces challenges due to students’ attitudes, abilities, and lack of resources. Nevertheless, he found that teachers tend to give positive feedback and show high acceptance towards the STEM approach. Alsmadi (2020)’s results confirm this positive attitude toward STEM practices and strategies in teachers.

### Teachers’ gender

Women continue to be underrepresented in STEM fields in educational and professional contexts in most countries, including the United States (Madden, Beyers, & O’Brien, 2016; Wang & Degol, 2017). Greenbaum and Hajjar (2017) reported barriers hindering women and minorities in STEM education. These barriers include cultural norms, which present women as homemakers. Furthermore, Isalm (2019) stated that while women’s access to education had increased, they still faced difficulty finding employment in STEM fields. However, the situation in schools has improved in many cases; as a result, female students often choose STEM courses at schools as frequently as their male peers (Ertl, Luttenberger, & Paechter, 2017). Suwono, Fachrunnisa, Yuenyong, and Hapsari (2019) indicated that increasing the representation of women in STEM fields might help combat gender-based stereotypes. Studies show that women feel less prejudice and categorization when they have female teachers for STEM subjects; moreover, engaging with female STEM teachers helps girls challenge their gender stereotypes and provides them with female role models (Benavent et al., 2020; Rainey, Dancy, Mickelson, Stearns, & Moller, 2019). Fighting stereotypes in the workplace requires developing a clear strategy and an end goal to ensure a teamwork environment that encourages relationships and includes women (Benavent et al., 2020; Rainey et al., 2019).

One common explanation for the gender disparity in STEM education or careers is individual choice (Madden et al., 2016). Many scholars, policymakers, and researchers argue that girls and women are less interested in and less likely to choose STEM professions because they are more interested in working with people than things (Kulturel-Konak, D’Allegro, & Dickinson, 2011). Overall, women value societal goals in their education and careers or desire to work directly with people, help others, and solve social problems (Charleston, Adserias, Lang, & Jackson, 2014; Sadler, Sonnert, Hazari, & Tai, 2012; Wang & Degol, 2017). In contrast, men are known for having proxy goals in their education and careers, including mastery, competitiveness, and accomplishments such as high wages (MacPhee, Farro, & Canetto, 2013). While societal goals are valued by all groups, including men (Weber, 2012), gender roles and cultural
norms emphasize concern for others as an endearing trait for women and some ethnic minority groups (Madden et al., 2016). Even among women with high self-efficacy in math and science, there is a negative relationship between group goal orientation and interest in STEM (Ertl et al., 2017; García-Peñalvo, Bello, Domínguez, & Chacón, 2019; Weber, 2012).

Despite the UN’s 2030 Sustainable Development (SD) Agenda goals to provide access to education and achieve gender equality, women and girls remain underrepresented, particularly in STEM (Darling-Hammond et al., 2020; Hand, Rice, & Greenlee, 2017; UNESCO, 2017). However, some Arab states, such as Oman and Saudi Arabia, have high rates of female STEM attainment, along with many other countries, including the USA, Switzerland, Spain, and Norway (World Economic Forum, 2020). The high rates of female STEM accomplishment raise the question of the actual level of female teachers’ participation in STEM in Jordan and Saudi Arabia.

Jordan seeks continuous improvement in education that enables male and female students to meet educational and economic challenges and find job opportunities (Alsmadi, 2020). This improvement policy has focused on reducing the gender gap and raising female participation rates in all domains, especially in STEM-related fields such as science and technology. However, this policy has been hindered by women’s cultural image. For instance, (Arabian Business Consultants for Development, 2017) reported to the British Council that female students in Jordan have relatively high-level access to educational services. Regardless, their participation in STEM-related jobs is low because women are seen as unqualified to take such positions due to cultural and societal perspectives. Interestingly, 62% of male secondary teachers perceived women as unhelpful and ineffective. Therefore, this report highlights a gender gap in women’s participation in STEM-related positions, including teaching.

The conservative restrictions and social norms in Saudi Arabia affect women’s lives (Mobaraki & Söderfeldt, 2010) and their education (Alhareth, 2013a). In addition, gender stereotypes and the power of the culture influence the shared beliefs of Saudis about particular fields; some specific careers, such as nursing, are considered female-domain (Abdul Razzak & Lee, 2016), as education and others, such as engineering, are considered male-domain (Hassan, 2000). In addition, the educational system plays a role in promoting gender stereotypes in schools. Teachers display strong gender stereotypes in the classrooms; ironically, they unconsciously reject that they bear these beliefs (Ifegbesan, 2010). Such beliefs impact teachers’ behavior toward their students, influencing their performance (De Kraker-Pauw, Van Wesel, Verwijmeren, Denessen, & Krabbendam, 2016). Sani (2018) highlights that female STEM graduates show limited participation in STEM-related jobs because of cultural norms and male domination in different fields. Moreover, because of societal pressure, most female STEM graduates prioritize family duties such as raising children rather than obtaining jobs.

**DISCUSSION, CONCLUSION AND SUGGESTIONS**

This study investigated STEM education implementations and teachers’ gender perspectives in classrooms. We considered the applications of STEM learning and the personal, environmental, and behavioral reasons behind the gender gap in implementing STEM education in the Jordanian and Saudi contexts. We have also analyzed women’s limitations and obstacles in STEM education and occupations. Our results showed that female teachers’ understanding of science, technology,
engineering, and mathematics education needed to be improved because females needed more interest in STEM disciplines. This weakness was attributed to a lack of self-efficacy and poor academic performance in STEM subjects, which was reflected in applying the STEM approach in classrooms.

It can be concluded that young women are more likely than men to enroll in higher education in STEM if they are encouraged and supported by their parents and teachers. However, scholars find that women are underrepresented in STEM professions, and many believe that this begins in secondary schools, where there need to be more female students enrolled in STEM subjects (Madani, 2020; Rico, Basurko, Ruiz-González, Palacios-Agundez, & Zuazagoitia, 2021). The participation, advancement, and accomplishments of girls and women in STEM education must be addressed, starting with the family to enable young women to unlock their potential and encourage them to enter the world of STEM.

Furthermore, changing teachers’ mindsets and attitudes will help dispel misconceptions about STEM education and inspire female students to pursue STEM degrees and professions. Additionally, rectifying the negative perceptions girls develop about STEM at a young age will help them embrace STEM subjects. Therefore, there is a need to encourage female STEM teachers to improve their skills in STEM education. The effect of teachers’ beliefs on students can have far-reaching consequences on the students’ learning (Screpanti et al., 2018). Furthermore, teachers can encourage their female students by engaging in informal discussions with them about STEM, sharing information, asking questions, and discussing their preferences.

Although various explanations have been offered for the gender disparity in STEM, this study expands upon the current literature by reviewing different personal, behavioral, and environmental factors that may explain gender differences. We found evidence that constraints exist in Saudi Arabia and Jordan that support the gender gap in STEM in many aspects, such as cultural norms (how women are perceived in society), the gender stereotypes that teachers display in the classrooms without their awareness (Ifegbesan, 2010), and the Saudi educational system promoting gender stereotypes in schools and higher education institutions, where women are not allowed to study some majors. For instance, Mills (2009) found that King Saud University did not offer engineering, archaeology, political science, and veterinary medicine programs for females. These norms and beliefs hinder women’s participation in STEM-related positions and lead to inequalities in employment. Furthermore, in the Jordan and Saudi contexts, there needs to be more understanding of teachers applying STEM education, and there is a need to develop more development programs to educate teachers about STEM practices. Therefore, this study recommends spreading more awareness about STEM education and practices. Moreover, there is a need to collaborate with educators and experts from countries that have achieved success with STEM education applications. Finally, decision-makers and policymakers in Jordan and Saudi must increase their cognition regarding STEM education.

Conflict of interest: The authors declare no conflict of interest.

ABOUT THE AUTHORS

Jehan Alghneimin is a Ph.D. candidate, currently studying within the European doctorate in Teacher education program, at Eötvös Loránd University, Budapest, Hungary. Her research interests are primarily focused on STEM education and gender disparities in science fields.
Attila Varga is an associate professor at the Institute of People–Environment Transaction at Eötvös Loránd University, teaching BA, MA, and Ph.D. levels in English and Hungarian. His main research interests are education of sustainability and environmental education, development of education and environmental psychology.

Monika Kovács is an associate professor at the Institute of Intercultural Education and Psychology at Eötvös Loránd University, teaching social psychology at BA, MA, and Ph.D. levels. She is an expert on anti-bias education; her main research interest is gender stereotypes and attitudes.

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