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High School Environment and Gender Diversity in Engineering: A Review of Academic Publication

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ABSTRACT

CONTEXT

According to research Science, Technology, Engineering and Mathematics (STEM) skills are associated as 75 per cent of the fastest-growing jobs in industries. From published data only 18% of graduated students in engineering fields are women creating a less balanced job market for these professional fields.

PURPOSE OR GOAL

This paper reviews research focused on attitudes towards gender diversity in STEM which are socially structured and realized through different kinds of educational systems. Existence of gender diversity in the social sustainability from the educational view leads to long lasting gender stereotypes attitudes in early learning and classrooms to higher educational systems. Teacher's behaviour is sometimes more important to motivate than transmit information. The STEM learning environment and teacher-student relationship are therefore important aspects of engagement in STEM classes and presents a vital new area of study.

APPROACH OR METHODOLOGY/METHODS

In this study, a thorough literature review has been conducted to include studies related to gender diversity and discussed the significant findings. Data collection techniques used in this article are literature review. Some articles related to STEM Education (Science, Technology, Engineering, Mathematics) have been read and those focusing on the relationship between teacher and students, and classroom environment (single-gender and co-educational school) studies were chosen.

ACTUAL OR ANTICIPATED OUTCOMES

This review paper aims to highlight how gender diversity in STEM education might be set up during the school period that leads to lower percentage of female students undertaking STEM and becoming STEM experts in future job market. Although lots of research focusing on the importance of the gender gap in STEM fields for years, it is still an area of concern in STEM education and careers. While gender diversity in STEM fields will be a worrying issue in future economic competition, changes are needed to be introduced to prepare for future economic challenges.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

The findings conclude that the interaction between teachers and students in STEM classrooms is significant for enhancing diversity in the STEM area. The atmosphere of schools and classrooms could be an important criterion for undertaking STEM as a profession. Reviewing different papers from different parts of the world indicated that gender diversity in STEM areas is considerable in most cultures. According to our findings, further research needs to be done on the teacher-student interactions in different classroom atmospheres (single-gender and co-educational schools) to fulfill the present gap.

KEYWORDS

Diversity, Teacher-student Interaction.

Introduction

Reinforcing students' abilities within Science, Technology, Engineering, and Mathematics (STEM) areas are considered significant for future financial and innovative development globally to create the idea that STEM jobs are "jobs of the future" (Andrews & Brown, 2015; English, 2016; Marginson et al., 2013; Science & Education, 2013; Sharma & Yarlagadda, 2018; Society, 2014). However, the Increasing percentage of female STEM experts influences economic and professional equality, educational variations and stereotypes leading to the decline of them in this fields (Update, 2017; Waite & McDonald, 2019). Moreover, number of research about sustainable development, which means equal opportunities in engineering education, demonstrating the importance of sustainability may help increase participation of women in engineering (Tsalaporta et al., 2021).

Schools are the first place that students become familiar with STEM and the teacher interaction in schools could have a direct impact on the students' ideas approach toward these fields. Besides it is intended to provide new vision to make changes in tertiary strategies to promote more female to choose engineering education (Carnemolla & Galea, 2021). Teachers play an important role in the process of student learning, and the communication between them influences the student outcomes (Chiang et al., 2019). According to Margot and Kettler (2019), confident STEM teachers could be influential in the STEM tasks and help to improve students' performance through activities that end up with success in students' learning. In addition, teachers' behaviours in the classroom reflect their ideas and prejudice which can consist of patriarchal and ethnocentric perspectives of science and learners (Kang & Zinger, 2019). Thus, improving teacher-student interaction will have a considerable effect on students' achievements.

According to the Australian Academy of Science, 17% of Australian university enrolments in engineering majors are women (McKinnon, 2022) which reveals the gender inequality in engineering education. Earlier reports highlight how the role of society, cultural aspects, and availability of role models and mentors at the school level effect on the student's decision to pursue STEM education at the higher level (Roberts et al., 2018; Sharma et al., 2019). females have to deal with certain challenges while stepping in to the STEM pipeline STEM education such as educational backdrop, environmental factors and elements which belong naturally and individually (Burke & Mattis, 2007; Lent et al., 2000; MEADOWS, 2016; Nugent et al., 2015; Sharma et al., 2019; Valla & Ceci, 2014; Wai et al., 2010; Wang & Degol, 2013).

To explore interest development, career choice, performance attainments, and persistence in STEM fields all around the world the Social Cognitive Career Theory (SCCT) (Lent et al., 1994, 2000; Sheu & Bordon, 2017) has been widely used (Fig. 1).

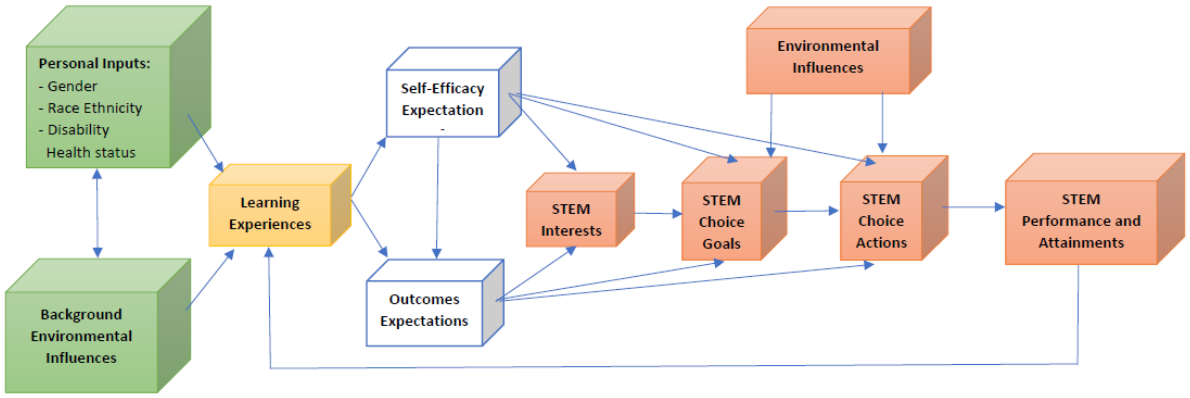

Fig. 1: The social cognitive career theory. Adapted from (Lent et al., 1994; Lent et al., 2005; Luttenberger et al., 2019)

According to this theory development of students' ideas about career and academic decision-making are processed by their interests (Lent et al., 2010). Effectiveness of Their interest

increased more when they can engage and maintain their individual abilities in person-environment interactions that enable their outcomes (Izard, 2007). Furthermore, individual students' beliefs and feeling through educational environment about their self-efficacy and outcomes can have effects on their interest in a specific area. There are various factors that may influence students' learning experiences in school environment and classrooms. Therefore, this review aims to discuss some of these factors that could be led to achieving a more effective gender diversity and equity in the STEM educational systems.

1.1 Single-Gender vs Co-educational STEM Classrooms

To improve gender diversity in the educational system, research suggested considering the supportive evidence of individual and environmental factors that can be the effect of a single-gender and co-educational learning atmosphere on female's performance and outcomes. Study by Almukhambetova et al. (2021) showed that, although there are talented girl students in STEM lessons graduated from high schools, they usually do not decide to continue STEM in their tertiary education. The underlying factors leading to their decision needs to be investigated further to develop more effective programs and supportive services assisting students to select courses according to their interest and talent.

According to Abraham and Barker (2020), Australian girl students from single-gender schools were more motivated in physics subjects than in co-educational schools. Koniewski and Hawrot (2021) also confirmed that girls from Polish single-gender schools could make better achievements in science subjects. In addition, the atmosphere of single-gender schools can also reduce the pressure of social views on male-dominant factors and girls feel more confident in their performances. According to the survey conducted by Yasin et al. (2020) in Pakistan, the educational system (single-gender/ co-educational) has not had a direct impact on student's academic achievements but on their self-esteem and confidence. Students from Iowa schools also agreed with the idea that they feel better in single-gender STEM classes and their scores increased through the program (Hassig, 2022). In some Australian single-gender schools, girls were more enrolled in STEM subjects than girls in co-educational, it is also for boys in different kinds of schools (Forgasz & Leder, 2020).

1.2 Teacher-Student Interaction

The classroom environment provides a dynamic social context for relationship developments and learning processes and the interactions between teachers and students has an important effect on the learning experience of students (Pennings & Hollenstein, 2020). The qualities of the relationship developed between teacher and student effect on longer term student performance, and will be a continuous process developing over time (De Boer et al., 2010). Interpersonal skills and students learning styles could have roles in development of these relationships and maintaining an active learning process during the school years. (Den Boer et al, 2010). Surveys provided by Ghafarpour et al. (2018), indicated that efficient communication between students and teachers leads to motivating students who are shy or lack the self-esteem to participate actively. There is also a significant impact of teacher interactions on students learning experience and outcomes in middle and high schools (Corbin et al., 2020; Ruzek & Schenke, 2019; Schenke et al., 2018). A study by Denessen et al. (2020) in Netherlands indicated that there is a relationship between teacher's behavior and students' achievements in math classes. Additionally, a study by Paredes (2022), highlighted the impact of the gender of a teacher on students in terms of being like a role model, typecast behaviours, and teacher preferences in relation to genders. Female Students who had female teachers gained higher scores than male teachers (Gong et al., 2018; Lim & Meer, 2020; Sansone, 2019). Also, the result of a survey in 2011 revealed that students in calculus class were more actively engaging in asking questions in classes run by female teachers (Stout et al., 2011). Based on Sullivan and Bers (2019), male instructors created more gender differences in robotic classes, while female instructors impacted girls' performance positively.

2. Methodology

In this study, a thorough literature review has been conducted to include studies related to gender diversity and discussed the significant findings. Since STEM education was targeted, “STEM” and “science, mathematics, technology, and engineering” were the primary phrases to start within the Scopus search engine. Regarding different explanations of STEM, it was decided to add “gender inequality”, “gender gap”, and “gender inequity” in the search terms. To expand the primary search, a different combination of these terms was used in the title, abstract, and keywords. To limit the literature search, we only included the articles published in the last five years (2018 to 2022). The abstracts of these articles were studied and those focusing on the interactions between teacher and students, the teacher gender effects on students, and single-gender and co-educational school studies were chosen.

3. Results and Findings

After carefully analysing the initial references, 34 articles were selected for this review. Most of these articles consider the gender gap as a significant issue in STEM classes and challenges faced by female students in co-educational schools. Single gender and co-educational environments have different impacts on the outcomes of female students. Girls in single-gender classrooms achieved higher math scores than girls in mixed-gender classrooms (Skital & Ţîru, 2021). Also, girls’ math outcomes were influenced positively by single-gender classrooms enhanced confidence(Cherney & Campbell, 2011; Forgasz et al., 2007; Paredes, 2022; Picho & Stephens, 2012) and produced a constructive classroom climate (Dijkstra & Berger, 2018). Moreover, it was showed that girls in Indian co-educational classrooms experienced high social anxiety that affected their performance and outcomes (Khadhijah & Vijaykumar, 2018).

According to the Australian study, female students from single-gender schools were motivated in physics subjects in comparison with girls in co-educational schools, because of devaluing the idea of masculinity (Abraham & Barker, 2020). Similar outcomes have been noticed in science classes in Poland where female students from single-gender schools received high scores in comparison to co-educational schools (Koniewski & Hawrot, 2021). Skital and Ţîru (2021), demonstrated that the female students studying in single-gender classrooms scored significantly higher than the ones studying in mixed-gender classrooms. Lee (2019), also stated that to have better outcomes, introducing a single-gender atmosphere for students could be effective. Besides, when students feel positive about single-gender classroom experiences same as their STEM identity may lead to being confident to think about STEM careers.

According to Sansone (2019) students’ performance and ideas were in a direct relationship with teachers’ ability in making topics interesting. Students lost their self-confidence when their teacher spread gender stereotypes about girls’ or boys’ abilities in math and science. Moreover, claimed that the expert and experienced STEM teachers behaved equally with boys and girls students (Sansone, 2019). Norwegian students who had sufficient classroom interaction which is influenced by their teachers’ behaviour become more motivated in class engagements (Havik & Westergård, 2020). The interviews conducted with teachers in Netherlands schools confirmed that the teacher-students interactions had a direct impact on the students’ outcomes (Denessen et al., 2020). Sullivan and Bers (2019), compared the students’ performance in robotic programs, in one of the public schools in Somerville, Massachusetts, with male and female instructors, the results showed that robotic female instructors promoted girls more to perform in the concept of coding. In a single-gender classroom, 60% of students stated that their self-confidence, participation, and desire were grown in completing the work (Lee, 2019).

4. Summary

This review paper focuses on gender inequity in STEM in the larger literature. Discussing the reason of gender diversity in engineering fields remains open in the literature. Among 34 articles, there were 3 articles from Africa, 10 Articles from America, 7 Articles from Asia, 6 articles from Australia and 8 Articles from Australia (Fig. 2).

Although, cultural stereotypes have effect on gender diversity in education, reviewing the different

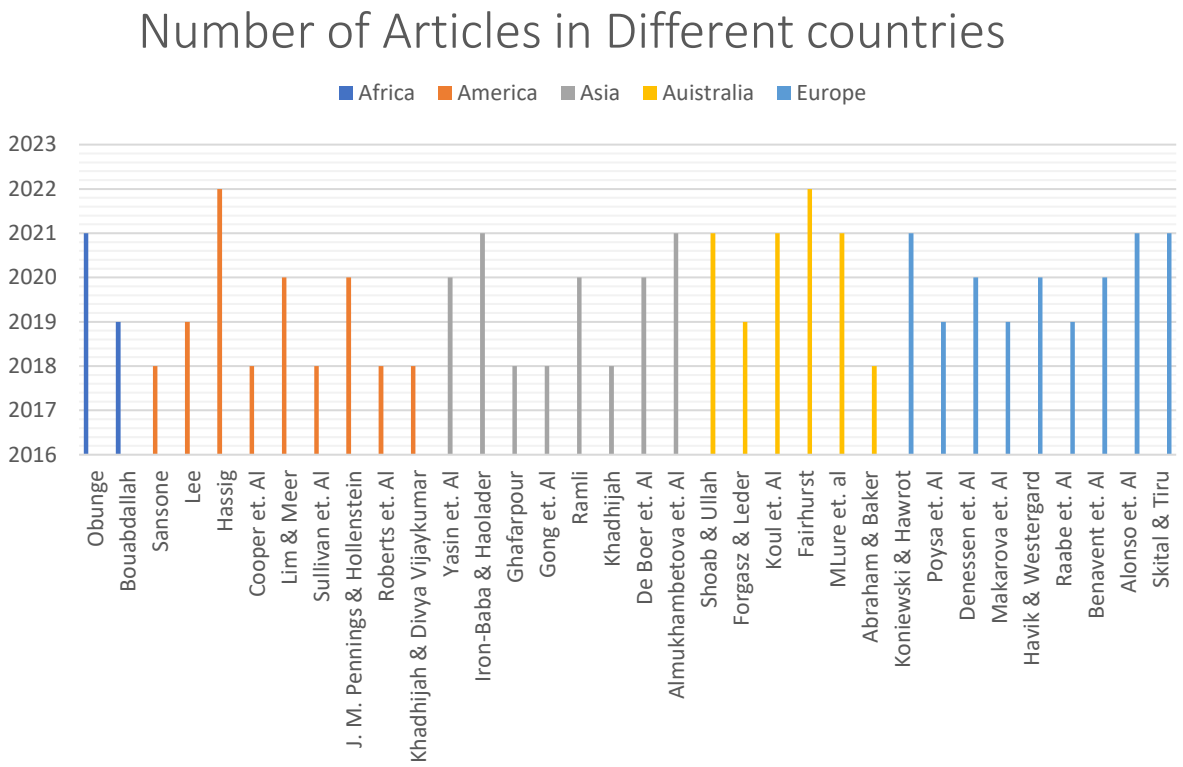

Fig.2. number of articles have been reviewed in different parts of the world.

studies around the world, highlighted the existing gap among different cultures. To overcome the gender diversity issue, eliminating the unsustainable negative attitude of girls toward mathematics from early learning is suggested. According to the psychological dimension of sustainability, gender equity in social and educational subjects can create long lasting idea of gender stereotypes from school-age children and their communities. Based on research female students in co-education schools experienced the highest social anxiety and in single-gender schools they feel more empowered to participation in STEM activities without the presence of male students.

By focusing on the effective factors on female's STEM achievements, it can be concluded that the interaction between teachers and students in STEM classrooms is significant in the girls' decisions to study in engineering majors. Considering how teacher–student interaction quality relates to engagement differently in STEM lessons for female and male students may leads to influence on students' decision in choosing engineering as their future major studying. The atmosphere of schools and classrooms, lack of role models, and cultural aspects can be also important in the creation of the gender diversity in STEM fields and careers. According to this review paper, further research needs to be done on the teacher-student interactions in single-gender and co-educational schools. there may be found reasons to decrease the gender gap in future engineering higher education fields and careers.

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