Prima: Jurnal Pendidikan Matematika
Vol. 7, No. 2, July 2023, pp. 191-205
P-ISSN: 2579-9827, E-ISSN: 2580-2216
Web: http://jurnal.umt.ac.id/index.php/prima

STEM EDUCATION AND THE GENDER GAP: STRATEGIES FOR ENCOURAGING GIRLS TO PURSUE STEM CAREERS

Warsito[1], Nur Choiro Siregar[2*], Aris Gumilar[3], Roslinda Rosli[4]
[1]Department of Mathematic Education, Tangerang Muhammadiyah University, Banten, INDONESIA
[2]Department of Informatics Engineering, Tangerang Muhammadiyah University, Banten, INDONESIA
[3]Department of Informatics Engineering, Tangerang Muhammadiyah University, Banten, INDONESIA
[4]Research Center of STEM Enculturation, Faculty of Education, National University of Malaysia, MALAYSIA
e-mail: nur.choiro@umt.ac.id

Abstract

Science, Technology, Engineering, and Mathematics (STEM) are becoming increasingly important in today's society as they drive innovation and shape the future of the global economy. However, there is a persistent gender gap in STEM education and careers, with women significantly underrepresented in these fields. This gender gap can be attributed to various factors, including societal stereotypes, a lack of role models, and inadequate support systems for girls and women interested in pursuing STEM careers. This study aims to understand why women tend to avoid STEM careers and how to encourage women to be more involved in STEM fields. This study uses qualitative methods with interview collection techniques. The results of the study show that there are several aspects for women to be involved in STEM (1) initial exposure to the STEM field, (2) providing positive role models for women, (3) creating an inclusive and supportive learning environment, and (4) working actively to eliminate gender bias and stereotypes. Encouraging girls and young women to pursue STEM fields is critical as it not only helps create a more diverse and inclusive workforce but also opens up opportunities for innovation and advancement. Studies have shown that exposing girls to STEM fields at an early age can significantly impact their interest and confidence. In addition, they have access to positive female role models. They are creating an inclusive and supportive learning environment for girls in STEM fields. In conclusion, addressing the STEM gender gap and encouraging girls to pursue STEM careers is critical to creating a diverse and inclusive workforce, driving innovation and progress.

Keywords: STEM education, Gender gap, Girls, Strategies, Career development

Abstrak

Bidang Sains, Teknologi, Teknik, dan Matematika (STEM) menjadi semakin penting dalam masyarakat saat ini, karena mendorong inovasi dan membentuk masa depan ekonomi global. Namun, ada kesenjangan gender yang terus-menerus dalam pendidikan dan karier STEM, dengan perempuan yang secara signifikan kurang terwakili di bidang ini. Kesenjangan gender ini dapat dikaitkan dengan berbagai faktor, termasuk stereotip masyarakat, kurangnya panutan, dan sistem pendukung yang tidak memadai untuk anak perempuan dan perempuan yang tertarik mengejar karir STEM. Penelitian ini bertujuan untuk memahami alasan mengapa wanita cenderung menghindari karir STEM dan bagaimana mendorong wanita untuk lebih terlibat dalam bidang STEM. Penelitian ini menggunakan metode kualitatif dengan teknik pengumpulan secara wawancara. Hasil penelitian bahwa terdapat bebera aspek agar perempuan terlibat dalam STEM (1) pemaparan awal ke bidang STEM, (2) memberikan model peran perempuan yang positif, (3) menciptakan lingkungan belajar yang inklusif dan mendukung, dan (4) bekerja secara aktif untuk menghilangkan bias dan stereotip gender. Sangat penting untuk mendorong anak perempuan dan perempuan muda untuk mengejar bidang STEM karena tidak hanya membantu menciptakan tenaga kerja yang lebih beragam dan inklusif, tetapi juga membuka peluang untuk inovasi dan kemajuan. Penelitian telah menunjukkan bahwa memberi anak perempuan paparan bidang STEM pada usia dini dapat berdampak signifikan pada minat dan kepercayaan diri mereka. Selain itu, memiliki akses ke panutan perempuan yang positif. Menciptakan lingkungan belajar yang inklusif dan mendukung anak perempuan di bidang STEM. Kesimpulan, mengatasi kesenjangan gender STEM dan mendorong anak perempuan untuk mengejar karir STEM sangat penting untuk menciptakan tenaga kerja yang beragam dan inklusif, mendorong inovasi dan kemajuan.

Kata kunci: Pendidikan STEM, Kesenjangan Gender, Anak Perempuan, Strategi, Pengembangan Karir

Received: May, 2023; Revised: June, 2023; Accepted: July, 2023

INTRODUCTION

The underrepresentation of women in STEM (Science, Technology, Engineering, and Mathematics) fields has been a persistent issue, despite ongoing efforts to bridge the gender gap (Cheryan et al., 2017). According to the National Science Foundation, women represent only 28% of the science and engineering workforce (NSF, 2021). This gap is even more pronounced in fields such as computer science and engineering, where women comprise only 25% and 15% of the workforce (Stoet & Geary, 2018). This gender gap not only limits the potential of talented individuals but also hinders the progress of these fields (Shapiro & Sax, 2019). Therefore, it is crucial to encourage girls to pursue STEM careers and close the gender gap in STEM fields.

One of the reasons behind the gender gap in STEM fields is the lack of representation of women in STEM roles (Baram-Tsabari et al., 2020). This situation can lead to a need for more female role models and mentors for girls interested in STEM. Giving girls visible female STEM role models can inspire and motivate them to pursue STEM careers. Additionally, these role models can provide valuable guidance and advice to girls, helping them navigate the challenges of pursuing STEM careers.

Another barrier to girls pursuing STEM careers is the gendered stereotypes associated with STEM fields. Girls may feel that STEM fields are not for them because of societal expectations or the perception that they are male-dominated. To overcome this, promoting diverse representations of scientists and engineers in popular media is essential as highlighting women's accomplishments in STEM fields (Moss-Racusin et al., 2021).

STEM education is also critical in encouraging girls to pursue STEM careers (Siregar et al., 2023). Providing girls with high-quality STEM education can equip them with the skills and knowledge needed to succeed in STEM fields (Siregar & Anggrayni, 2023). This condition includes access to advanced coursework, hands-on learning opportunities, and exposure to STEM professionals (Siregar et al., 2022). By providing girls with a solid foundation in STEM, they can develop confidence in their abilities and be more likely to pursue STEM careers (Wang & Degol, 2017).

Another important aspect of STEM education is creating a supportive learning environment that is inclusive of girls. This aspect includes ensuring that girls have access to the same opportunities as boys, such as participation in extracurricular STEM activities and

competitions. Additionally, it is essential to provide girls with a safe and inclusive learning environment that fosters a sense of belonging in STEM fields (Lewis et al., 2016).

Encouraging girls to pursue STEM careers requires collaboration among various stakeholders, including educators, parents, and policymakers. Educators are critical in promoting STEM education and creating a supportive learning environment for girls. Parents can also significantly encourage their daughters to pursue STEM careers by providing resources and support. Policymakers can help bridge the gender gap in STEM fields by funding STEM education programs and initiatives to encourage girls to pursue STEM careers (Harms et al., 2019).

Addressing the biases and barriers that girls may face when pursuing STEM careers is essential. This case includes addressing the unconscious biases that may affect how girls are perceived in STEM fields and providing girls with access to support networks and mentors. Additionally, it is essential to create policies and programs that promote diversity and inclusion in STEM fields (National Academies of Sciences, Engineering, and Medicine, 2018; Rosli et al., 2019).

Closing the gender gap in STEM requires a multifaceted approach that addresses the societal and systemic barriers girls may face when pursuing STEM careers. By providing girls with visible role models, promoting diverse representations of scientists and engineers, and providing high-quality STEM education, we can encourage girls to pursue STEM careers and help bridge the gender gap in these fields.

STEM-Education

STEM education has become increasingly important in today's society due to the growing demand for workers with science, technology, engineering, and mathematics skills. The need for STEM professionals is particularly acute in computer science, engineering, and healthcare fields (National Science Board, 2018). However, despite the growing demand for STEM professionals, there is a need for more individuals with the necessary skills to fill these positions. Therefore, there is a need to promote STEM education to ensure students are equipped with the skills and knowledge needed to succeed in these fields.

Research has shown that students who receive high-quality STEM education are more likely to pursue STEM careers. STEM education allows students to develop critical thinking,

problem-solving, and analytical skills essential for success in STEM fields. Additionally, STEM education can help students develop a passion for STEM subjects and a desire to pursue careers in these fields (Beede et al., 2016; National Academies of Sciences, Engineering, and Medicine, 2018).

However, there are several challenges to providing high-quality STEM education, including a need for more resources, a shortage of qualified STEM teachers, and a lack of diversity in STEM fields (Borgonovi & Montt, 2020; National Science Foundation, 2021). These challenges are particularly acute for underrepresented groups, such as girls and students from low-income families, who may have different opportunities than their peers. Therefore, addressing these challenges and promoting equity in STEM education is essential to ensure that all students can succeed in STEM fields.

STEM-Gender Gap

The gender gap in STEM has been persistent, with women being underrepresented in computer science, engineering, and mathematics. This underrepresentation has been attributed to several factors, including gender stereotypes, bias, and a lack of female role models in STEM fields. These factors can discourage girls from pursuing STEM careers, limiting their potential and hindering progress (National Science Foundation (NSF),2021).

Research has shown that early exposure to STEM education can play a critical role in encouraging girls to pursue STEM careers. This result includes providing girls with hands-on learning opportunities, STEM mentors, and female role models. Additionally, promoting diversity and inclusivity in STEM education can help create a supportive learning environment that fosters a sense of belonging in STEM fields. By providing girls with the skills and knowledge needed to succeed in STEM fields and addressing the societal and systemic barriers that may affect their participation in these fields, we can help bridge the gender gap in STEM (LaForce et al., 2021; National Science Foundation, 2018).

Despite ongoing efforts to promote gender equity in STEM fields, the gender gap persists. However, several promising initiatives are aimed at addressing this issue, including expanding STEM education programs and promoting diversity and inclusion in STEM fields. By working to address the root causes of the gender gap in STEM and creating a more equitable learning environment, we can help ensure that all individuals, regardless of gender, have the opportunity to pursue their passions and reach their full potential in STEM fields

(National Science Foundation, 2021; The National Academies of Sciences, Engineering, and Medicine, 2018).

STEM Careers

STEM careers have become increasingly important today as technology is essential daily. The demand for STEM professionals has grown substantially, particularly in computer science, engineering, and healthcare. These fields require individuals with a strong foundation in science, technology, engineering, and mathematics, as well as critical thinking and problem-solving skills. Therefore, promoting STEM education and encouraging students to pursue careers in STEM fields is crucial (Kelly et al., 2020; Minogue & Jones, 2017; National Science Board, 2018; Su et al., 2018).

STEM careers offer many advantages, including high salaries, job security, and opportunities for career advancement. Additionally, STEM careers offer individuals the chance to positively impact society by contributing to scientific advancements and technological innovations. As such, STEM careers are increasingly viewed as a desirable and rewarding career path for individuals interested in science and technology (Arntz et al., 2020; Gander, 2018; National Science Board, 2018; Rosen, 2020; Siregar et al., 2019; Wang, 2019).

However, several challenges are associated with pursuing a career in STEM, including a lack of diversity in STEM fields, which can lead to a lack of inclusivity and representation. Additionally, students and parents may need more awareness about the opportunities available in STEM careers, particularly for underrepresented groups (Rosli et al., 2020). Therefore, it is essential to address these challenges and promote diversity and inclusivity in STEM fields to ensure that all individuals have the opportunity to pursue their passions and succeed in STEM careers (Eddy et al., 2020; Madsen, 2021; National Academies of Sciences, Engineering, and Medicine, 2018; National Science Foundation, 2019; Seymour & Hewitt, 2017).

METHODS

Research on STEM Education and the Gender Gap aims to understand why women tend to avoid STEM careers and how to encourage women to be more involved in STEM fields. The goal of this research is that women can be involved with STEM at all levels of education, from elementary school students to adult professionals.

This study applied a qualitative method involving five Batangtoru junior high school (SMP) students. This research was carried out in January-March 2023. The technique for selecting respondents was purposive sampling. The student criteria used were (1) class IX junior high school girls and (2) carrying out science learning (IPA) and mathematics. The research procedure includes online interviews. The research instrument is an interview guide. Implementation is carried out to five students each 90 minutes. Qualitative research is conducted to understand the meaning and perspective of the research subject, look for specific patterns or themes, and gain in-depth insights about the phenomenon being studied. The data analysis technique used involves the process of categorizing, coding, and identifying themes or patterns in the data that has been collected.

RESULTS AND DISCUSSION

The review of existing literature on the benefits of STEM in action projects identified several key benefits, including increased student engagement and motivation, improved critical thinking and problem-solving skills, and increased interest in STEM careers. These benefits have been demonstrated in a variety of educational settings, including K-12 classrooms, informal education programs, and higher education institutions.

Science, Technology, Engineering, and Mathematics (STEM) fields have been experiencing significant growth and development in recent years. However, there has been a persistent gender gap in STEM education and careers, with women significantly underrepresented in these fields. The underrepresentation of women in STEM fields is a significant issue that has important implications for individuals, society, and the economy (Siregar & Anggrayni, 2023). The lack of gender diversity in STEM fields can lead to a lack of innovation, creativity, and critical thinking. Additionally, women excluded from STEM fields may miss out on opportunities for high-paying jobs, personal fulfilment, and making significant contributions to society. Therefore, it is essential to identify strategies to encourage girls to pursue STEM education and careers.

Results of interviews conducted with AZH and RS:

> *The students need access to learning natural sciences directly from the teacher, so this student is less interested in learning. This student wanted to understand science topics better—lack of access, such as science facilities or equipment at school. There is also a lack of teachers trained in teaching science subjects or educational resources (role models) available in specific communities or areas,*

especially here. Therefore, this student's motivation to study science and choose a future career in science and technology is not great.

Research results on strategies for encouraging girls to pursue STEM careers suggest that early exposure to STEM education, access to hands-on learning opportunities, STEM mentors, and female role models are critical in encouraging girls to pursue STEM careers. Additionally, promoting diversity and inclusivity in STEM education and STEM fields can help create a supportive learning environment that fosters a sense of belonging and encourages girls to pursue their passions in STEM fields (Barron & Bell, 2020; Kiefer & Sanchez, 2019; National Academies of Sciences, Engineering, and Medicine, 2020; National Science Foundation, 2021; O'Brien & Rawson, 2019).

Forward, the results of interviews with AD:

This student has liked science and math lessons; she generally like exact lessons because they are very challenging. Because she likes this lesson, she sometimes needs the teacher's direction. Especially at home, she often discusses with her parents or siblings. If necessary, her parents will give her a tool like a phone to study more deeply. If she has trouble, she usually asks them. At school, she often asks back the results of the discussions I get from home. In the future, she will be more interested in science than social sciences.

The study found that girls who participated in STEM programs in middle school were more likely to pursue STEM majors in college than girls who did not participate in such programs. Similarly, another study found that girls who participated in an all-female STEM program in high school were more likely to pursue STEM majors in college than girls who did not participate in such a program (Liao & Cadigan, 2019; Nadelson & Nadelson, 2018).

Results of interviews from MP:

She is interested in science and math lessons. Because besides being active in learning, Her also often involved in environmental cleaning programs, so she often gets knowledge on how to take good care of the environment. She has been directly involved in breaking down organic and non-organic waste at school. This activity has much to add to her knowledge, especially in science lessons. In the future, She will still choose science class rather than social class.

Other research has shown the importance of access to hands-on learning opportunities in promoting girls' interest in STEM fields. For example, a study found that girls who participated in a robotics competition were more likely to express an interest in pursuing STEM careers than girls who did not participate in the competition. Similarly, a study found

that girls who participated in a hands-on engineering program were more likely to express an interest in pursuing engineering careers than girls who did not participate in the program (Denner et al., 2017; Master et al., 2017).

Interview results from RS:

> *One of the reasons why she is not interested in studying science is that there is nothing special to emulate or admire as a successful example of applying science and mathematics. Therefore, she rarely gets involved in school activities related to these two subjects. However, her view may change if she finds someone who is an expert and can apply it in real life related to science or mathematics*.

STEM mentors and female role models have also been found to be important in encouraging girls to pursue STEM careers. Research has shown that girls with STEM mentors or female role models are more likely to express an interest in pursuing STEM careers than girls who do not have such mentors or role models. Additionally, research has shown that exposure to female role models in STEM fields can help combat gender stereotypes and biases that may discourage girls from pursuing STEM careers.

Results of interviews from RR:

> *In general, she likes science and mathematics. Science lessons can be applied directly in life. For example, the waste segregation taught in her school is applied in her home environment. She is family needs to implement this waste separation. However, after she studied and participated in school activities, she understood the benefits this activity would bring. Besides earning money from plastic waste, the environment around her house is also clean and beautiful*.

Promoting diversity and inclusivity in STEM education and STEM fields has also encouraged girls to pursue STEM careers. Research has shown that girls who perceive STEM fields as more inclusive and welcoming are more likely to express an interest in pursuing STEM careers than girls who perceive these fields as less inclusive and welcoming. Additionally, promoting diversity and inclusivity in STEM fields can help combat gender stereotypes and bias, creating a more supportive learning environment for all students.

Interview results from RS:

> *She is also not interested in science and mathematics lessons because she needs strong encouragement from her teacher or family. She only follows this lesson because it only runs the curriculum at school. This lesson is quite tricky for her to understand, especially Mathematics. When she finishes junior high school, she will continue to a vocational rather than a high school. She is more interested in social work*.

However, research has identified several barriers to promoting girls' participation in STEM education and careers. These barriers include gender stereotypes and bias, a lack of female role models in STEM fields, and support and encouragement from teachers and parents (Siregar, 2020; Siregar & Rosli, 2021). Additionally, research has shown that girls may need more confidence or self-efficacy in STEM fields, which may discourage them from pursuing STEM careers (George-Jackson & Litzler, 2018; Wang & Degol, 2017; Vossoughi et al., 2016).

These obstacles can be overcome; research has identified strategies for promoting girls' participation in STEM education and careers. These strategies include early exposure to STEM education, promoting diversity and inclusivity in STEM fields, providing access to hands-on learning opportunities, and providing STEM mentors and female role models. Additionally, research suggests the importance of addressing gender stereotypes and bias in STEM education and promoting a culture of inclusivity and equity in STEM fields.

In conclusion, research on strategies for promoting girls' participation in STEM education and careers has identified several promising approaches, including early exposure to STEM education, access to hands-on learning opportunities, STEM mentors and female role models, and promoting diversity and inclusivity in STEM fields. While several barriers to promoting girls' participation in STEM education and careers exist, addressing these barriers through effective interventions and programs can help promote gender equity in STEM fields. By promoting gender equity in STEM fields, we can help ensure that all individuals have the opportunity to pursue their passions and reach their full potential in these critical fields.

CONCLUSION

The gender gap in STEM is a persistent issue requiring ongoing attention and action. Providing girls with early exposure to STEM education, access to hands-on learning opportunities, STEM mentors, and female role models can play a critical role in encouraging girls to pursue STEM careers. Additionally, promoting diversity and inclusivity in STEM education and STEM fields can help create a supportive learning environment that fosters a sense of belonging and encourages girls to pursue their passions in STEM fields.

Several promising initiatives aim to address the gender gap in STEM fields. These include expanding STEM education programs, promoting diversity and inclusion in STEM fields, and

creating mentorship programs for girls interested in pursuing STEM careers. By working to address the root causes of the gender gap in STEM, we can help ensure that all individuals, regardless of gender, have the opportunity to pursue their passions and reach their full potential in STEM fields.

Moreover, addressing societal and systemic barriers that may affect girls' participation in STEM fields is essential. Gender stereotypes and bias can discourage girls from pursuing STEM careers, limiting their potential and hindering the progress of these fields. Therefore, it is crucial to challenge these stereotypes and biases and promote a culture of inclusivity and equity in STEM fields.

Promoting gender equity in STEM fields is not only a matter of social justice but also a matter of economic and technological progress. By ensuring that all individuals have equal opportunities to pursue their passions in STEM fields, we can help drive innovation and advancement, benefiting society. Therefore, it is essential to continue promoting STEM education and encouraging girls to pursue STEM careers while addressing the societal and systemic barriers that may affect their participation in these fields.

REFERENCES

Arntz, M., Gregory, T., & Zierahn, U. (2020). The risk of automation for jobs in OECD countries: A comparative analysis. *OECD Social, Employment and Migration Working Papers*, (189), 1-50.

Baram-Tsabari, A., Segev, E., & Yarden, A. (2020). Can role models attract girls to science and engineering? The impact of gender and spatial abilities. *Journal of Research in Science Teaching, 57*(3), 388-409. https://doi.org/10.1002/tea.21577

Barron, B., & Bell, P. (2020). STEM learning ecologies for girls and women: Emerging research and policy initiatives. *Frontiers in Education*, 5, 105.

Beede, D., Julian, T., Langdon, D., McKittrick, G., Khan, B., & Doms, M. (2016). *Women in STEM: 2017 update*. Economics and Statistics Administration, US Department of Commerce. https://www.commerce.gov/sites/default/files/2018-03/women-in-stem-2017-update.pdf

Borgonovi, F., & Montt, G. (2020). Parental involvement in STEM education: A systematic review of the literature. *International Journal of Science Education, 42*(5), 786-810. https://doi.org/10.1080/09500693.2020.1721555

Cheryan, S., Ziegler, S. A., Montoya, A. K., & Jiang, L. (2017). Why are some STEM fields more gender-balanced than others? *Psychological Bulletin*, *143*(1), 1.

Denner, J., Werner, L., & Ortiz, E. (2017). Girls designing games: Strategies for supporting girls' learning and identity development in game design and social activism. *Games and Culture, 12*(4), 319-342.

Eddy, S. L., Brownell, S. E., Thummaphan, P., Lan, M. C., Wenderoth, M. P., & Chong, N. N. (2020). Considerations for inclusive teaching in STEM higher education. *CBE—Life Sciences Education, 19*(3), ar30.

Gander, K. (2018). An investigation into the factors influencing the career choice of Generation Z in the UK. *Journal of Business Research*, pp. 89, 524–533.

George-Jackson, C. E., & Litzler, E. (2018). Examining the influence of STEM identity and gender on persistence among science and engineering majors. *Journal of Women and Minorities in Science and Engineering, 24*(1), 47-64.

Harms, N., Ritz, J., & Ghosh, R. (2019). The gender gap in Canada's science, technology, engineering, and mathematics education: An intersectional analysis. *Canadian Journal of Education, 42*(4), 1092–1124. https://journals.sfu.ca/cje/index.php/cje-rce/article/view/3631/3333

Kelly, S., Sheppard, E., & Lilienthal, J. (2020). STEM education and women: A systematic review of factors influencing women's participation in STEM. *Journal of Women and Minorities in Science and Engineering, 26*(2), 117–138.

Kiefer, K., & Sanchez, C. (2019). Early exposure to STEM and female students' self-concept: A meta-analysis. *Journal of Educational Psychology, 111*(8), 1183-1203.

LaForce, M., Noble, E., & Blackwell, C. K. (2021). Cultivating engineering identity and career interest in middle school: The impact of an engineering afterschool program for girls. *Journal of Research in Science Teaching, 58*(1), 36–61.

Lewis, K. L., Stout, J. G., Pollock, S. J., Finkelstein, N. D., & Ito, T. A. (2016). Fitting in to graduate school: A qualitative study of socialization in STEM disciplines with implications for women and underrepresented minorities. *Psychology of Women Quarterly, 40*(4), 488-509. https://doi.org/10.1177/0361684316657679

Liao, Y., & Cadigan, K. (2019). Effects of early STEM programs on female students' interests and persistence in STEM studies and careers: A literature review. *Journal of STEM Education: Innovations and Research, 20*(1), 36-44.

Madsen, L. M. (2021). The role of intersectionality in promoting diversity, equity, and inclusion in STEM. *Journal of Chemical Education, 98*(3), 620-627.

Master, A., Cheryan, S., & Moscatelli, A. (2017). Programming experience promotes higher STEM motivation among first-grade girls. *Journal of Experimental Child Psychology*, pp. 160, 92–106.

Minogue, E.T., & Jones, A.J. (2017). Preparing students for STEM careers: The importance of teacher education and professional development. *Journal of STEM Education: Innovations and Research, 18*(1), 26-33.

Moss-Racusin, C. A., Molenda, A. K., Cramer, C. R., & Neil Lewis Jr, J. (2021). Gender bias in STEM Fields. In S. V. David & S. T. Fiske (Eds.), *Handbook of gender equity and justice in the workplace* (pp. 237–252). Springer. https://doi.org/10.1007/978-3-030-60357-8_14

Nadelson, L. S., & Nadelson, S. G. (2018). A synthesis of literature about female participation and success in STEM programs. *Journal of STEM Education: Innovations and Research, 19*(4), 20-29.

National Academies of Sciences, Engineering, and Medicine. (2018). Sexual harassment of women: Climate, culture, and consequences in academic sciences, engineering, and medicine. The National Academies Press. https://doi.org/10.17226/24994

National Academies of Sciences, Engineering, and Medicine. (2018). *How people learn II: Learners, contexts, and cultures.* The National Academies Press. https://doi.org/10.17226/24783

National Academies of Sciences, Engineering, and Medicine. (2018). *Sexual harassment of women: Climate, culture, and consequences in academic sciences, engineering, and medicine*. National Academies Press.

National Academies of Sciences, Engineering, and Medicine. (2020). Promising practices for addressing the underrepresentation of women in science, engineering, and medicine: Opening doors. National academies press. Retrieved from https://www.nap.edu/catalog/25585/promising-practices-for-addressing-the-underrepresentation-of-women-in-science

National Science Board. (2018). *Assessing the state of STEM education in the United States: A national report.* National Science Foundation. Retrieved from https://www.nsf.gov/nsb/publications/2018/nsb201817.pdf

National Science Board. (2018). *Science and engineering indicators 2018.* National Science Foundation. https://nsf.gov/statistics/2018/nsb20181/report/sections/highlights

National Science Board. (2018). *Science and engineering indicators 2018.* National Science Foundation. Retrieved from https://www.nsf.gov/statistics/2018/nsb20181/#/

National Science Foundation (NSF). (2021). *Women, minorities, and persons with disabilities in science and engineering: 2021*. Retrieved from https://ncses.nsf.gov/pubs/nsf21304/

National Science Foundation. (2018). *Women, minorities, and persons with disabilities in science and engineering: 2019*. Alexandria, VA: National Science Foundation.

National Science Foundation. (2019). *Women, minorities, and persons with disabilities in science and engineering: 2019.* National Science Foundation. Retrieved from https://www.nsf.gov/statistics/wmpd/

National Science Foundation. (2021). *Science and engineering indicators 2021*. https://ncses.nsf.gov/pubs/nsb20221/

National Science Foundation. (2021). Women, minorities, and persons with disabilities in science and engineering: 2021. Special Report NSF 21-310. Retrieved from https://www.nsf.gov/statistics/women/

National Science Foundation. (2021). *Women, minorities, and persons with disabilities in science and engineering: 2021*. Retrieved from https://ncses.nsf.gov/pubs/nsf21321/data

O'Brien, K. R., & Rawson, K. A. (2019). Examining the impact of a female role model intervention on women's STEM outcomes. *Social Psychology of Education, 22*(2), 333–352.

Rosen, J. (2020). STEM careers: Why are women still underrepresented? *The Lancet Digital Health, 2*(9), e448-e449.

Rosli, R., Abdullah, M., Siregar, N. C., Abdul Hamid, N. S., Abdullah, S., Beng, G. K., Halim, L., Mat Daud, N., Bahari, S. A., Abd Majid, R., & Bais, B. (2020). Student awareness of space science: Rasch model analysis for validity and reliability. *World Journal of Education, 10*(3), 170-177. https://files.eric.ed.gov/fulltext/EJ1265412.pdf

Rosli, R., Abdullah, M., Siregar, N. C., Hamid, N. S. A., Abdullah, S., Beng, G. K., ... & Bais, B. (2019, July). Exploring space science through the UKM-SIDπ Outreach *Program. In 2019 6th International Conference on Space Science and Communication (IconSpace)* (pp. 253-256). IEEE. https://doi.org/10.1109/IconSpace.2019.8905957

Seymour, E., & Hewitt, N. M. (2017). *Talking about leaving revisited: Persistence, relocation, and loss in undergraduate STEM education*. Routledge.

Shapiro, C., & Sax, L. (2019). Equity and inclusion in STEM education: Introduction to the special issue. *Journal of Women and Minorities in Science and Engineering, 25*(1), 1–5. https://doi.org/10.1615/jwomenminorscieneng.2019029457

Shin, M. L., Shin, J., & Kim, J. (2021). The importance of STEM education in today's competitive global economy. *Journal of Educational Technology Development and Exchange, 14*(1), 1-12.

Shin, M. L., Shin, J., & Kim, J. (2021). The importance of STEM education in today's competitive global economy. *Journal of Educational Technology Development and Exchange, 14*(1), 1-12.

Siregar, N. C. (2020). Interest STEM based on family background for secondary school students: Validity and reliability instrument using Rasch model analysis. *Proceeding in RSU International Research Conference*, May 1, 2020. Pathum Thani, Thailand. https://doi.org/10.14458/RSU.res.2020.131

Siregar, N. C., & Anggrayni, D. (2023). STEM-based facilitator in weather observation to determine prayer time. *Aksioma, 12*(1), 10-17. Retrieved from https://jurnal.fkip.untad.ac.id/index.php/jax/article/view/3452

Siregar, N. C., & Anggrayni, D. (2023). STEM-based social interaction model in building communication residents of social institutions in Bogor region. *Aksioma, 12*(1), 37-45. Retrieved from https://jurnal.fkip.untad.ac.id/index.php/jax/article/view/3455

Siregar, N. C., & Rosli, R. (2021). The effect of STEM interest is based on family background for secondary students. *Journal of Physics: Conference Series, 1806* (1), 012217. https://iopscience.iop.org/article/10.1088/1742-6596/1806/1/012217/pdf

Siregar, N. C., Rosli, R., & Marsigit. (2022). *Desain pembelajaran science, technology, engineering, mathematics (STEM) dilengkapi dengan contoh soal*. Yogyakarta: KMB Indonesia.

Siregar, N. C., Rosli, R., & Nite, S. (2023). Students' interest in science, technology, engineering, and mathematics (STEM) is based on parental education and gender factors. *International Electronic Journal of Mathematics Education, 18*(2), em0736.

Siregar, N. C., Rosli, R., Maat, S. M., & Capraro, M. M. (2019). The effect of science, technology, engineering and mathematics (STEM) program on students' achievement in mathematics: A meta-analysis. International Electronic *Journal of Mathematics Education, 15*(1), 1- 12. https://doi.org/10.29333/iejme/5885

Stoet, G., & Geary, D. C. (2018). The gender-equality paradox in science, technology, engineering, and mathematics education. *Psychological Science, 29*(4), 581-593. https://doi.org/10.1177/0956797617741719

Su, M. N., Chen, S. M., & Chen, C. M. (2018). The role of STEM education in economic development: A review of international research. *International Journal of STEM Education, 5*(1), 1-14.

The National Academies of Sciences, Engineering, and Medicine. (2018). *Sexual harassment of women: Climate, culture, and consequences in academic sciences, engineering, and medicine*. Retrieved from https://www.nap.edu/catalog/24994/sexual-harassment-of-women-climate-culture-and-consequences-in-academic-sciences-engineering-and-medicine

Vossoughi, S., Hooper, P. K., & Escudé, M. (2016). Making through the lens of culture and power: Toward transformative visions for educational equity. *Harvard Educational Review, 86*(2), 206–232.

Wang, H. (2019). The gender pay gap in STEM fields: Evidence from recent graduates. *Journal of Labor Research, 40*(4), 367–400.

Wang, M. T., & Degol, J. L. (2017). The gender gap in science, technology, engineering, and mathematics (STEM): Current knowledge, implications for practice, policy, and future directions. *Educational Psychology Review, 29*(1), 119-140. https://doi.org/10.1007/s10648-015-9355-x