Assessing the Effectiveness of STEM Activities in Enhancing Motivation among Secondary School Students: Enhancing Technology Integration

Tahira Yasmeen[1]

Abstract

This study examines how STEM (science, technology, engineering, and mathematics) education affects students' motivation levels from the viewpoints of 10th graders in district Sialkot and Faisalabad as well as secondary school teachers. The study recruited 400 students and 50 teachers and used quantitative analysis to evaluate variables like interest levels, learning orientation, autonomy, confidence, and overall motivation. To address the designed research questions, a rating scale was used to collect data. There were no discernible gender variations in teachers' and students' perceptions of how STEM education affected these motivating qualities, according to independent sample t-tests. According to both groups, STEM education improves motivation and related factors for both genders. These results imply that STEM education creates a fair learning environment and balances student passion and involvement. To maintain and improve student motivation, the study suggests providing equitable access to STEM opportunities and resources for all genders, as well as activities that foster confidence, student-centered learning strategies, and useful, entertaining STEM applications.

Keywords: *STEM education, Motivation level, Secondary school level.*

Introduction

STEM education science, technology, engineering, and mathematics—is crucial in the fast-paced world of modern technology. It provides students with the foundational skills necessary to thrive in the highly technologically advanced world of today, including creativity, problem-solving, and critical thinking. Teaching complex concepts and encouraging hands-on learning, STEM education equips students for a range of career opportunities in in-demand sectors including engineering, healthcare, and information technology. STEM education also promotes innovation and economic growth. It drives technological advancements that improve living conditions and address global concerns, including climate change and medical discoveries. In addition, early exposure to STEM fields fosters diversity and inclusivity by closing gender and racial gaps in these fields.

[1] Tahira Yasmeen, Assistant Professor, School of Education, Minhaj University Lahore
Email: tahira92yasmeen@gmail.com

https://doi.org/10.58932/MULI0012

A workforce that is competent and skilled, ready to take on new challenges and guide society toward a more prosperous and sustainable future, is ensured by having a strong STEM foundation (Barker, Welch, & Wu, 2015). The foundation for future academic and professional success is laid and a love of learning is successfully fostered in secondary STEM education. These hands-on activities, realistic experiments, and real-life problem-solving stimulate young minds and humanize complex concepts. Early exposure demystifies challenging subjects, including mathematics and physics, making them less intimidating and more approachable. At this point, the exercises promote cooperation, creativity, and critical thinking. Teaching kids to ask questions, seek information, and collaborate with peers can enhance their social and cognitive development.

Furthermore, these exercises cater to a range of learning preferences, ensuring that all students may participate and benefit from them (King, 2015). STEM education helps uncover and cultivate potential talents and interests in these topics, setting students on a path to pursue STEM-related degrees and careers. All things considered, a strong foundation for lifetime learning and creativity is established by early STEM education (Li, Forbes, & Yang, 2021). Students' motivation is greatly increased by these activities since they can make studying engaging and relevant. When students see how their knowledge is used in the real world through interactive projects, practical experiments, and problem-solving in real-life circumstances, their curiosity and enthusiasm are sparked.

By turning abstract concepts into tangible events, experiential learning makes subjects like math and physics more understandable and enjoyable (de Roock, & Baildon, 2019). Through these activities, children are given agency by taking charge of their own education. By promoting exploration and discovery, they help their pupils develop a growth mentality that empowers them to take on challenges and learn from their failures. Self-worth is cultivated and continued engagement is encouraged by this independence and sense of accomplishment (Gupta, Fraser, Rank, Brucker, & Flinner, 2019). Collaborative STEM projects enhance social skills and teamwork, which in turn promote a positive learning environment. When students work together to solve problems, they become even more motivated because it creates a sense of community and a shared objective. Ultimately, STEM-related activities inspire pupils to pursue STEM-related careers and further education by cultivating a love of learning.

Objectives of the study

The following are the main research objectives for this proposed study:

1. To know the effect of STEM activities on the motivation level of secondary school students as perceived by teachers.
2. To find out the effect of STEM activities on the motivation level of secondary school students as perceived by students.

Research Questions

1. What is the effect of STEM activities on the motivation level of secondary school students as perceived by teachers?
2. What is the effect of STEM activities on the motivation level of secondary school students as perceived by students?

Literature Review

Background of STEM Education

A more integrated STEM approach includes measures and evaluations of student learning, links between activities and resources, and relationships between disciplines. According to a different study, students must take part in research and engineering design projects that relate to fundamental subjects as well as science, math, and engineering activities (Gupta, Voiklis, Rank, Dwyer, Fraser, Flinner, & Nock, 2020).

The problems with the current era's information explosion actually lie with the people and their culture. Technology, society, politics, and the economy have all undergone radical change as a result of the growth of STEM (LópezLeiva, Roberts-Harris, & von Toll, 2016). Similar to numerous other developing nations across the globe, Pakistan is only now realizing the importance of STEM and beginning to incorporate it into school curricula.

According to Rahm (2019), incorporating STEM into the curriculum at educational institutions presents a variety of difficulties. A teacher can easily organize and prepare his lectures given his knowledge and skills. In addition, he can develop methods and resources for content delivery and facilitate resource sharing among students (Morrissey, Heimlich, & Schatz, 2020). STEM reinvents conventional approaches by fusing these four fields into a single meta-discipline (Nugent, Barker, Welch, Grandgenett, Wu, & Nelson, 2015). Unfortunately, most STEM education makes little attempt to incorporate these courses (Struyf, et. al., 2019). In addition to improving topic memory, student-centered integrated STEM education enhances higher-order thinking and problem-solving skills.

According to Robert (2018), success is achievable for educators who utilize the previously listed teaching tactics. According to Yelland and Waghorn (2020), STEM is mostly problem-solving oriented, where students are required to apply their understanding of science and math, engineering construction abilities, and technology use for research, design, and testing to solve problems (Solanki et al., 2019). Additionally, they must provide their responses in an environment that combines verbal exchange with interactive, group learning. Effective teaching techniques are necessary for STEM education to be successful, and these techniques have long been a cause of concern for some educators (Agbejoye, & Oke, 2019).

Not many educators have the knowledge and abilities needed to operationalize STEM teaching. Over time, students gain a deeper comprehension of the fundamental STEM concepts that drive STEM involvement, including curiosity

and engagement. Bao (2020) states that the study's main goal is to determine how important STEM education is for teachers. It is challenging for administrators and teachers to use this area of the school in a way that is appropriate (Fan and Yu, 2017). Consequently, on every outcome indicator, the academic STEM group outperformed the educational STEM group.

Social and Financial Benefits of STEM

Through the implementation of various strategies, such as the capacity approach, to regulate the way in which well-being and quality of life are measured, this kind of learning lessens marginalization and promotes social and economic benefits for communities. STEM education is an integrated curriculum approach, as opposed to a content-based approach that may aid in the development of skills and lifetime learning capacity. Teaching, training, and preparation in the broadest sense—that is, giving students the skills they need to deal with the constantly shifting needs of businesses and society—are often the responsibilities of educational institutions, according to Harris & De Bruin (2017). The landscape of education has changed as a result of the new skill set needed for the twenty-first century.

But given that some educational models remain relevant, educators should reconsider their traditional responsibilities as information producers and redefine themselves as learning facilitators, in keeping with constructivist principles (Kelly, Dowling, & Millar, 2018). The problems that STEM programs face require the effective application and integration of STEM to find solutions. A wide range of scientific and technical activities are presented to students due to the variety of problems that can be resolved by using a STEM approach. Students encounter and contextualize what they are learning as a result of working through difficulties that have personal meaning for them.

In order to maintain the competitiveness of our society, Madani (2019) contends that STEM perspective also provides teachers with valuable experiences by assisting with group projects and science-related problem solving. Transformational learning and discourse are having an increasing impact on the development of STEM education methodologies (Larkin, Shaw, & Flowers, 2019). Undoubtedly, the nation's future rests on the understanding that while not everyone is motivated to work in STEM fields, those who are should nonetheless receive encouragement and support. To support educators who choose to work in STEM schools and to prepare future STEM educators, a comprehensive approach to professional development will be necessary (Mallette, & Saldaña, 2019).

Students' Motivation for Learning

One important aspect of motivation that has a big impact on students' academic performance and engagement is their degree of confidence. Students are more inclined to take on challenges and persevere through hardships when they have confidence in their own skills. Confidence in one's talents boosts intrinsic motivation and cultivates a positive attitude toward learning, according to Bandura's self-efficacy theory (Bandura, 1997). Increased eagerness to participate and a decreased fear of

failure are two characteristics of motivated learners that are correlated with high confidence. Thus, it is crucial in educational environments to promote confidence through encouraging feedback and attainable goals (Schunk & Pajares, 2002).

Students' motivation is the degree of autonomy, particularly when considering self-determination theory. Participating in educational activities out of real curiosity or personal value as opposed to outside pressures is known as autonomous motivation. Students are more likely to exhibit perseverance, creativity, and deeper learning when they have a sense of autonomy. Encouraging autonomy in learning environments boosts intrinsic motivation, which improves academic performance and increases personal fulfillment. Teachers may foster a more motivated and self-directed learner by providing meaningful options, promoting self-initiative, and honoring students' viewpoints.

The term "learning-oriented level" describes a student's innate drive to comprehend and excel in academic material as opposed to just getting good grades or surpassing their peers. Self-determination theory, which highlights the value of autonomy, competence, and relatedness in promoting deep learning, is strongly related to this aspect of motivation. Pupils that are highly motivated to learn are more likely to use effective study techniques, persevere through difficulties, and exhibit more academic resilience. Curiosity and a sincere desire to learn are often the driving force behind these students' long-term academic achievement and personal development (Pintrich, 2003).

Student motivation in educational settings is their degree of interest. Learners are more likely to engage deeply, persevere through difficulties, and produce superior learning outcomes when they are genuinely engaged in a subject. Intrinsic motivation, which motivates pupils to learn for its own reason rather than in pursuit of rewards from other sources, is bolstered by interest. Additionally, studies indicate that classes that are in line with students' interests boost engagement, enjoyment, and attention (Renninger & Hidi, 2016). As a result, encouraging student interest is essential to ensuring long-term motivation and academic achievement.

Research Methodology

This research study employed quantitative data analysis as a descriptive method. Participants in the study were all 10th grade students and secondary school teachers. Sialkot and Faisalabad districts were the study's accessible population. The study's sample was selected based on demographics related to gender and location. The study included 400 students in the tenth grade and fifty secondary school teachers. The sample was selected through convenient sampling techniques. As the researcher wants to collect data from teachers and students from secondary classes, that’s why keeping in view the gender and locality sample was collected conveniently. To get accurate perception regarding STEM education a five-point rating scale was developed. Instructions for the questionnaire were given to the students and teachers

also. The independent sample t-test was employed to address the study problems with the help of the SPSS software. Below is the data analysis:

Table 1: *Gender-Wise Comparison of Teachers' Perception Regarding Effect of STEM Education on Students' Motivation Level*

Teachers	N	M.	Std. Dev.	t-value	Sig.
Male teachers	27	3.807	.433	-.94	.35
Female teachers	23	3.916	.379		

The perspectives of male and female teachers regarding the effect of STEM education on students' motivation levels are compared using a t-test in the table. The mean motivation level perception for males, with 27 male and 23 female respondents, is 3.807 (SD = 0.433), while it is somewhat higher for females, at 3.916 (SD = 0.379). With a p-value of 0.35, the t-value mentioned in the table is -0.94. Male and female educators hold comparable perspectives regarding the ways in which STEM education affects students' motivation levels.

Table 2: *Gender-Wise Comparison of Teachers' Perception Regarding Effect of STEM Education on Students' Confidence Level*

Teachers	N	M.	Std. Dev.	t-value	Sig.
Male teachers	27	3.552	.607	-1.31	.20
Female teachers	23	3.787	.662		

The table examines how STEM education affects students' confidence levels, which is a crucial component of motivation, according to male and female teachers. The mean confidence level for 27 male respondents is 3.552 (SD = 0.607), although it is marginally higher for 23 female respondents at 3.787 (SD = 0.662). In the table above, t value is -1.31 and significance level is .20. Therefore, there is no discernible gender difference in the way that both genders evaluate how STEM education affects students' confidence, according to the statistics.

Table 3: *Gender-Wise Comparison of Teachers' Perception Regarding Effect of STEM Education on Students' Autonomous Level*

Teachers	N	M.	Std. Dev.	t-value	Sig.
Male teachers	27	4.197	.467	-.95	.35
Female teachers	23	4.323	.470		

The opinions of male and female educators on how STEM education influences students' autonomy a crucial component of motivation—are contrasted in Table 3. The mean perception score for 27 male professors is 4.197, with a standard deviation of 0.467. The mean score for the twenty-three female teachers is 4.323, with a standard deviation of 0.470, which is marginally higher. As mentioned above significance level 0.35, advocate that teacher, whether male and female, have comparable perspectives about how STEM education affects students' degrees of autonomy. There does not appear to be a significant gender difference in the ways that the two genders perceive how STEM education promotes student autonomy.

Table 4: *Gender-Wise Comparison of Teachers' Perception Regarding Effect of STEM Education on Students' Learning Oriented Level*

Teachers	N	M.	Std. Dev.	t-value	Sig.
Male teachers	27	3.579	.548	-.21	.84
Female teachers	23	3.613	.607		

The views of male and female educators on the influence of STEM education on students' learning-oriented level—a critical component of motivation—are contrasted in Table 4. The mean impression score of 3.579 (SD = 0.548) for 27 male respondents and 3.613 (SD = 0.607) for 23 female respondents are presented in the table. T-value of -0.21 and p-value of 0.84 are the results of the t-test. This shows that views on how STEM education influences students' disposition toward learning are almost the same for male and female educators. There is significant unanimity across the genders, with no discernible difference in their opinions, as seen by the near mean scores and high p-value.

Table 5: *Gender-Wise Comparison of Teachers' Perception Regarding Effect of STEM Education on Students' Interested Level*

Teachers	N	M.	Std. Dev.	t-value	Sig.
Male teachers	27	3.812	.590	.21	.83
Female teachers	23	3.848	.674		

Table 5 compares teachers' opinions about how STEM education affects students' interest levels—a crucial component of motivation—based on their gender. According to the data, there are 27 male professors, and their mean perception score is 3.812. The mean score for the twenty-three female professors is 3.848, with a standard deviation of 0.674. A p-value of 0.83 mentioned a substantial unanimity between male and female teachers on this element is suggested by the modest difference in mean scores.

Table 6: *Gender-Wise Comparison of Students' Perception Regarding Effect of STEM Education on Students' Motivation Level*

Students	N	M.	Std. Dev.	t-value	Sig.
Male students	205	3.495	.56:	1.46	.144
Female students	195	3.416	.507		

The impact that STEM education has on students' motivation levels is compared for male and female students in Table 6. The mean perception score of 205 male students (SD = 0.568) and 195 female students (SD = 0.507) are displayed in the table. A t-value of 1.46 and a p-value of 0.144 are obtained from the t-test. This shows that students' perceptions of how STEM education affects their motivation are similar for male and female students. The non-significant t-value and close mean scores suggest that gender is not a significant factor in determining students' perceptions of the motivational influence of STEM education.

Table 7: *Gender-Wise Comparison of Students' Perception Regarding Effect of STEM Education on Students' Confidence Level*

Students	N	M.	Std. Dev.	t-value	Sig.
Male students	205	3.510	.713	-1.31	.20
Female students	195	3.763	.659		

Students' assessments of how STEM education affects their confidence levels—a crucial component of motivation—are compared for male and female students in Table 7. The mean confidence level score among 205 male students is 3.510 (SD = 0.713). The mean score for 195 female students is 3.763 (SD = 0.659), which is higher. A t-value of -1.31 and a p-value of 0.20 are the outcomes of the t-test study. This suggests that although female students tend to express somewhat higher levels of confidence in STEM education, the difference is not significant enough to be taken into account. When it comes to how STEM education affects their confidence, both sexes hold similar opinions.

Table 8: *Gender-Wise Comparison of Students' Perception Regarding Effect of STEM Education on Students' Autonomous Level*

Students	N	M.	Std. Dev.	t-value	Sig.
Male students	205	3.387	.677	-.95	.35
Female students	195	3.252	.696		

Table 8 compares students' assessments, by gender, of how STEM education has affected their degrees of autonomy, which is a crucial component of motivation. According to the statistics, 195 female students had a mean autonomy score of 3.252 with a standard deviation of 0.696, somewhat lower than the 205 male students' mean score of 3.387 with a 0.677 standard deviation. A p-value of 0.35 and a t-value of -0.95 are obtained from the t-test. This shows that opinions about how STEM education affects students' feeling of autonomy are shared by male and female students alike.

Table 9: *Gender-Wise Comparison of Students' Perception Regarding Effect of STEM Education on Students' Learning Oriented Level*

Students	N	M.	Std. Dev.	t-value	Sig.
Male students	205	3.549	.663	-.21	.84
Female students	195	3.285	.691		

Students' assessments of how STEM education affects their learning-oriented level—a crucial component of motivation—are compared between male and female students in Table 9. The average score for 205 male students is 3.549 with a 0.663 standard deviation, while the average score for 195 female students is marginally lower at 3.285 with a 0.691 standard deviation. T-value of -0.21 and p-value of 0.84 are the results of the t-test. This shows that the perspectives of both genders regarding how STEM education influences their learning orientation are similar. There is no discernible

gender-based difference, as seen by the modest difference in mean scores and the high p-value, which points to substantial alignment in their opinions.

Table 10: *Gender-Wise Comparison of Students' Perception Regarding Effect of STEM Education on Students' Interested Level*

Students	N	M.	Std. Dev.	t-value	Sig.
Male students	205	3.348	.569	.33	.74
Female students	195	3.329	.559		

A comparison of how male and female students perceive the impact of STEM education on their interest levels—a crucial component of motivation—is shown in Table 10. According to the table, there are 205 male students, and the mean perception score is 3.348 with a standard deviation of 0.569. The mean score for 195 female students is 3.329, with a standard deviation of 0.559, which is extremely close. The t-value and p-value from the t-test are 0.33 and 0.74, respectively. This suggests that the opinions of male and female students on the influence of STEM education on their interest levels are almost the same.

Discussion

There is no statistically significant gender-based differences in teachers' and students' perceptions of how STEM education affects different aspects of motivation, such as general motivation, confidence, autonomy, learning orientation, and interest, according to the current study's findings, which are based on Tables 1 through 10. With all p-values far over the traditional threshold of significance ($p > .05$), these results are consistent both male and female groups, suggesting that perceptions of the motivational benefits of STEM education are uniform across gender lines.

These results are consistent with previous research that indicates STEM education has a positive impact on motivation-related aspects in students of all genders. For instance, Sahin (2013) discovered that STEM-integrated curriculum increases students' intrinsic motivation and engagement, which is supported in the current study by the comparable mean scores that male and female students reported. Effective STEM teaching methods can also universally increase students' self-confidence, curiosity, and capacity for independent learning, according to Margot and Kettler (2019). A common professional understanding and acceptance of the motivational benefits of STEM instruction is suggested by the equal perceptions of male and female teachers (Tables 1–5). This confirms the findings of Wang and Degol (2017), who found that teachers of all genders typically see STEM education as a means of encouraging students to think more critically and to be more independent.

Furthermore, gender-neutral attitudes are also reflected in the student-based data (Tables 6–10), supporting the idea that STEM education has a universally stimulating impact. This is consistent with research by Maltese and Tai (2011), who discovered that while participating in practical, real-world STEM learning activities, both male and female students demonstrated higher motivation. The Christensen, Knezek, and Tyler-Wood (2015) study also found that well-designed STEM programs

successfully encourage equal confidence and involvement among students of all genders. It's crucial to compare these results with other studies that indicate enduring gender disparities in STEM-related motivation and attitudes. For instance, even when classroom experiences are intended to be gender-neutral, cultural and societal variables may nevertheless have an impact on girls' interest and involvement in STEM courses (Blickenstaff, 2005; Stoet & Geary, 2018). This suggests that even while perceived motivation is equal in the current study, underlying societal barriers can still exist and require more qualitative investigation.

Furthermore, although not statistically significant, the current study discovered that female teachers and students had somewhat higher mean scores in the majority of categories (such as autonomy and confidence). This pattern is somewhat consistent with research by Shin, Sutherland, Shin, Conroy, and Sosniak (2021), who discovered that female students, especially in collaborative STEM settings that prioritize inclusivity and relevance to societal issues, tend to report higher emotional and motivational responses. There is no discernible gender bias in the research supporting the efficacy of STEM education in raising student motivation. This is a good sign that STEM teaching methods are becoming more inclusive. However, given established institutional and cultural hurdles, future research should use mixed-method and longitudinal approaches to examine if perceived similarities translate into equitable participation, achievement, and persistence in STEM disciplines.

Conclusion

When it comes to general motivation, confidence, autonomy, learning orientation, and interest levels, male and female educators have similar opinions. This shows that educators, of both genders, agree on its importance. Students, both male and female, believe that STEM education has a comparable better effect on their motivation in terms of general motivation, self-assurance, autonomy, learning style, and interest levels. This shows that STEM education, independent of gender, consistently increases students' motivation. Although male and female students' confidence levels differ slightly after receiving STEM education, this difference is not statistically significant. Therefore, it can be concluded that STEM education, regardless of gender, plays a similar role in raising students' confidence levels. Both male and female instructors as well as students of both sexes believe that STEM education promotes student autonomy.

This suggests that STEM education promotes independence and self-reliance equally for all students, regardless of gender. Students, both male and female, report that STEM education has led to a similar increase in interest. This constancy highlights how well STEM education works to pique kids' interest and encourage participation, regardless of gender.

Recommendations:

1. To sustain this balanced motivation level between genders, schools should make sure that opportunities, resources, and support systems are available to male and female students on an equal basis.
2. Teachers can include activities that specifically help students gain confidence in their abilities, like group projects, presentations, and problem-solving exercises, in STEM curricula in order to increase students' self-assurance and promote equitable participation.
3. Schools can use more student-centered learning strategies in STEM classes to increase this impact. This may entail giving students the chance to conduct independent research, work on self-directed projects, and choose their own learning paths, all of which would help them develop a sense of responsibility and self-control.
4. Educational establishments should incorporate interesting, practical applications of STEM principles into the curriculum since STEM education has a favorable impact on students' motivation and learning orientation.

References

Agbejoye, S. J., & Oke, S. (2019). Class size and gender as determinant of students' performance in electrical courses in colleges of education in Lagos state. *International Journal of Business Tourism and Applied Sciences (IJBTS), 6*(2), 199-220.

Bandura, A. (1997). Self-efficacy: The exercise of control. New York: Freeman. Schunk, D. H., & Pajares, F. (2002). The development of academic self-efficacy. In A. Wigfield & J. S. Eccles (Eds.), *Development of Achievement Motivation* (pp. 15–31). San Diego, CA: Academic Press.

Bao, W. (2020). COVID-19 and online teaching in higher education: A case study of Peking University. *Human Behavior and Emerging Technologies, 2*(2), 113-115.

Barker, B., Welch, G., & Wu, C. (2015). A model of factors contributing to STEM learning and career orientation. *International Journal of Science Education, 37*(7), 1067–1088. https://doi.org/10.1080/09500693.2015.1017863.

Blickenstaff, J. C. (2005). Women and science careers: Leaky pipeline or gender filter? *Gender and Education, 17*(4), 369–386. https://doi.org/10.1080/09540250500145072

Christensen, R., Knezek, G., & Tyler-Wood, T. (2015). Gender differences in high school student dispositions toward science, technology, engineering, and mathematics careers. *Journal of Computers in Mathematics and Science Teaching, 34*(4), 395–408.

De Roock, R. S., & Baildon, M. (2019). My skills future for students, STEM learning, and the design of neoliberal citizenship in Singapore. *Cognition and Instruction, 37*(3), 285–305. https://doi.org/10.1080/07370008.2019.1624545

Fan, S. C., & Yu, K. C. (2017). How an integrative STEM curriculum can benefit students in engineering design practices. *International Journal of Technology and Design Education, 27*(1), 107-129.

Gupta, R., Fraser, J., Rank, S. J., Brucker, J. L., & Flinner, K. (2019). Multi-site case studies about zoo and aquarium visitors' perceptions of the STEM learning ecology. *Visitor Studies, 22*(2), 127–146. https://doi.org/10.1080/10645578.2019.1661737

Gupta, R., Voiklis, J., Rank, S. J., Dwyer, J. de la T., Fraser, J., Flinner, K., & Nock, K. (2020). Public perceptions of the STEM learning ecology–perspectives from a national sample in the US. *International Journal of Science Education, 10*(2), 112–126. https://doi.org/10.1080/21548455.2020.1719291

Harris, A., & De Bruin, L. R. (2017). Secondary school creativity, teacher practice and STEAM education: An international study. *Journal of Educational Change, 19*(2), 153- 179.

Kelly, M., Dowling, M., & Millar, M. (2018). The search for understanding: The role of paradigms. *Nurse Researcher, 25*(4), 9-13.

King, D. (2015). STEM learning through engineering design: fourth-grade students' investigations in aerospace. *International Journal of STEM Education, 2*(1). https://doi.org/10.1186/s40594- 015-0027-7

Larkin, M., Shaw, R., & Flowers, P. (2019). Multi perspectival designs and processes in interpretative phenomenological analysis research. *Qualitative Research in Psychology, 16*(2), 182-198.

Li, H., Forbes, A., & Yang, W. (2021). Developing culturally and developmentally appropriate early STEM learning experiences. *Early Education and Development 32*(1), 1–6). https://doi.org/10.1080/10409289.2020.1833674

LópezLeiva, C., Roberts-Harris, D., & von Toll, E. (2016). Meaning making with motion is messy: developing a STEM learning community. *Canadian Journal of Science, Mathematics and Technology Education, 16*(2), 169–182. https://doi.org/10.1080/14926156.2016.1166293

Madani, R. A. (2019). Analysis of educational quality, a goal of education for all policy. *Higher Education Studies, 9*(1), 100-109.

Mallette, L., & Saldaña, J. (2019). Teaching qualitative data analysis through gaming. *Qualitative Inquiry, 25*(10), 1085-1090.

Margot, K. C., & Kettler, T. (2019). Teachers' perception of STEM integration and education: A systematic literature review. *International Journal of STEM Education, 6*(1), 1–16. https://doi.org/10.1186/s40594-018-0151-2

Maltese, A. V., & Tai, R. H. (2011). Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among U.S. students. *Science Education, 95*(5), 877–907. https://doi.org/10.1002/sce.20441

Morrissey, K., Heimlich, J. E., & Schatz, D. (2020). Redefining professionalism for the informal STEM learning field. *Museum Management and Curatorship,*

https://doi.org/10.1080/09647775.2020.1803109

Nugent, G., Barker, B., Welch, G., Grandgenett, N., Wu, C. R., & Nelson, C. (2015). A model of factors contributing to STEM learning and career orientation. *International Journal of Science Education, 37*(7), 1067–1088. https://doi.org/10.1080/09500693.2015.1017863

Pintrich, P. R. (2003). A motivational science perspective on the role of student motivation in learning and teaching contexts. *Journal of Educational Psychology, 95*(4), 667–686.

Rahm, J. (2019). The re-storying of STEM learning through the lens of multiples. *Cognition and Instruction 37*(3), 408–413. https://doi.org/10.1080/07370008.2019.1624550

Renninger, K. A., & Hidi, S. (2016). *The power of interest for motivation and engagement*. Routledge.

Roberts, T. (2018). Students' perceptions of STEM learning after participating in a summer informal learning experience. *Stem Education Journal, 12*(3), 19-30. https://stemeducationjournal.springeropen.com/articles/10.1186/s40594-018-0133-4

Sahin, A. (2013). STEM clubs and science fair competitions: Effects on post-secondary matriculation. *Journal of STEM Education: Innovations and Research, 14*(1), 5–11.

Shin, J., Sutherland, L. M., Shin, S. Q., Conroy, M. A., & Sosniak, L. A. (2021). Gender differences in motivational beliefs in STEM and the role of learning environments. *Contemporary Educational Psychology, 65*, 101947. https://doi.org/10.1016/j.cedpsych.2021.101947

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

Struyf, A., De Loof, H., Boeve-de Pauw, J., & Van Petegem, P. (2019). Students' engagement in different STEM learning environments: integrated STEM education as promising practice? *International Journal of Science Education, 41*(10), 1387–1407. https://doi.org/10.1080/09500693.2019.1607983

Wang, M. T., & Degol, J. L. (2017). Gender gap in 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

Yelland, N., & Waghorn, E. (2020). STEM learning ecologies: collaborative pedagogies for supporting transitions to school. *International Journal of Early Years Education, 18*(6), 211-232. https://doi.org/10.1080/09669760.2020.1863193