INNER
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www.innovativedu.org Volume 7, Issue 1, 2025

Investigating Middle School Students' Perceptions of Different Types of Performance-Based Science Learning Activities*

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Abstract

There has been a significant expectation all over the world to participate in students in Science, Technology, Engineering and Mathematics (STEM). However, both recruitment and interest in STEM related career choices decreased. Therefore, the aim of this research was to explore middle school students' attitudes on performance-based science education. In this descriptive survey study participants were 226 middle school students. Data was collected during 2022-2023 fall term from middle schools (5th to 8th grade). Data collection tool was adapted and implemented. The data collection tool has different types of questions including demographic, Likert types, and open ended. For this reason, as a data analysis both qualitative analysis methods were used in order to observe differences in gender and grade level. According to the results, less middle school students want to pursue career in STEM related jobs. Most boys thought that engineering is a male job whereas nursing is a female job. Also, some of the girls think that jobs have no gender. In addition, both girls and boys know more male scientists than female scientists. Almost half of the middle school students did not state any woman scientist. Other findings stated that most of them have positive perceptions about science is important but ironically most of them said that science is not for them but clever people. This research's findings have implications to gender stereotypes and career aspirations in STEM.

Keywords: STEM education, gender stereotypes, middle school students, perceptions, career aspirations

To cite this article: Özergun-Köse, I., & Timur, B. (2025). Investigating Middle School Students' Perceptions of Different Types of Performance-Based Science Learning Activities. *Innovative Educational Research (INNER), 7,* (1), 8-20.

Article Type	Received	Accepted	Published Online
Research Article	03.23.2025	05.24.2025	05.31.2025

*Preliminary findings of this paper were presented in European Science Education Research Association (ESERA) Congress occurred in Cappadocia, Türkiye, from August 28 to September 1, 2023. This paper is also supported by Canakkale Onsekiz Mart University Scientific Research Projects number 4258.

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Statement of Literature

In the modern world, there is an increasing demand for individuals to pursue careers in the fields of science, technology, engineering, and mathematics, specifically called (STEM). On the contrary, science education literature has highlighted that younger generations exhibit a declining preference for STEM-related jobs (McGaw, 2008; Osborne & Dillon, 2008). This trend has raised concerns regarding the potential shortage of scientists and engineers in the future global workforce (Gough, 2015). Addressing this significant issue, as fostering a positive attitude, interest, and career decision-making process toward STEM disciplines among students is critical for selecting professional jobs in these fields in the future (Tekerek & Karakaya, 2017).

Science education literature has demonstrated that while students often exhibit a positive interest in science during their early educational years, this interest declines significantly by the time they reach the end of middle school (Archer et al., 2010). One contributing factor to this decline is the perceived disconnect between the science contents in classroom and science contents in real-world applications. Despite the importance of science and expressing that it is exciting and engaging, many students fail to see themselves scientists or engineers in the future (Regan & DeWitt, 2014). This dispersal between student perceptions of science and their sense of self-efficacy within the field presents a significant barrier to their continued interest and involvement in STEM-related jobs. In addition, it is essential for educational programs to bridge the gap between school science and its real-life applications. The integration of more relevant, hands-on, and inquiry-based science education approaches could foster a deeper connection between students lived experiences and the scientific concepts they study in school (Simpson & Bouhafa, 2020). Moreover, emphasizing the diverse career in STEM and showcasing role models who reflect the students' own backgrounds could help students envision themselves as future professionals in these fields (Malagrida et al., 2022). The early intervention of STEM applications is crucial for individual academic and career success and the advancement of societies that increasingly rely on scientific and technological innovations (Tytler & Ferguson, 2023).

The existing literature suggests the need for educational interventions that not only maintain but also enhance students' engagement with STEM-related disciplines from their early years. Efforts to promote STEM education should focus on creating more inclusive and relatable science curricula that resonate with students' interests and daily experiences (Gandhi-Lee et al., 2017). Additionally, providing opportunities for students to engage with real-life scientific problems and solutions could further investigate the field and allow students to see the tangible impact of science on society (Littledyke, 2008). In this way, educators and policymakers can work together to develop strategies that not only prevent the decline in STEM interest during adolescence but also inspire the next generation of scientists, engineers, and innovators. Thus, ensuring a sustainable future workforce in STEM requires performance-based applications (Villanueva Baselga et al., 2022). By addressing the educational and psychological factors that contribute to the decline in students' interest in science during critical periods of development, stakeholders in education can create learning environments where all students are encouraged and equipped to pursue STEM careers. This situation will contribute to the broader goal of fostering innovation and addressing global challenges that require scientific and technological solutions (Archer et al., 2010). There are pronounced

gender disparities in career preferences, with significantly fewer women pursuing STEM-related jobs compared to men. This gender gap in STEM participation has been a persistent issue, and several factors have been identified as contributing to the underrepresentation of women in these fields (Shen et al., 2016). According to Blickenstaff (2005), a range of influences such as biological differences between genders, a lack of interest in science and mathematics, the scarcity of female role models in STEM professions, and cultural pressures from families, teachers, and society at large all play a role in dissuading young women from selecting careers in STEM. These factors collectively create a social and educational environment that can undermine girls' confidence in their abilities to succeed in these fields, reinforcing traditional gender norms and occupational segregation (Zhan et al., 2022).

Cultural and societal expectations have a significant impact on career preferences and choices, particularly for women in STEM. Kahle et al. (1993) similarly found that societal expectations, along with students' prior experiences, shape their future career decisions. From a young age, girls often receive implicit and explicit messages about which subjects and careers are "appropriate" for them. These messages can come from various sources, including parents, educators, peers, and the media, and often reflect deep-seated cultural stereotypes that portray STEM as a male-dominated domain. As a result, many young women may internalize the belief that they do not belong in STEM, even if they demonstrate the same aptitude and interest in science and mathematics as their male counterparts (Archer et al., 2010). The middle school years have been identified as a critical period in shaping students' future career trajectories. Research has shown that the experiences and attitudes formed during middle school can have a lasting impact on students' career choices, particularly in relation to STEM fields (Osborne, 2007; van Griethuijsen et al., 2015). For girls, negative attitudes toward science and mathematics during this period can significantly reduce the likelihood of pursuing STEM careers. This decline in interest is often explained by the lack of female representation in STEM related jobs, both in the classroom and in professional settings, which further reinforces the perception that these fields are not welcoming to women (English, 2016).

One key challenge in addressing this issue is the deeply ingrained nature of gender stereotypes and biases that influence educational and career for future. To overcome these stereotypes, it is essential for educational applications to focus on fostering a more inclusive and supportive learning environment for all students, particularly during the middle school years (Tytler & Ferguson, 2023). This includes providing access to female role models in STEM, designing an instructional design that might change gender stereotypes, and encouraging girls to engage in hands-on, inquiry-based learning experiences that build confidence in their science and math skills (Yesilkaya et al., 2023). Furthermore, teachers play a crucial role in shaping students' perceptions of STEM. Research suggests that teachers' own biases and expectations can influence how they interact with students, which can, in turn, affect students' self-efficacy and interest in pursuing STEM careers (Camilli & Hira, 2019). By fostering a classroom culture that promotes equity and inclusiveness, teachers can help combat the cultural pressures that often discourage girls from pursuing STEM. Professional development programs for teachers that emphasize the importance of gender equity in STEM education can be instrumental in creating such an environment (Bennett & Hogarth, 2009).

In conclusion, the underrepresentation of women in STEM is a complex issue that stems from a combination of societal, cultural, and educational factors. Efforts to address this issue must begin early in students' educational environments, particularly during the middle school years when career interests and attitudes are still forming (Dost, 2024). By creating

supportive, inclusive environments that challenge traditional gender norms and providing girls with the tools and encouragement they need to succeed in STEM, educators and policymakers can help close the gender gap and ensure that more women are able to pursue careers in these critical fields (Morgan et al., 2016). Ultimately, increasing women's participation in STEM is not only a matter of equity but also essential for driving innovation and progress in science and technology (Gandhi-Lee et al., 2017).

Significance of Study

Researchers have emphasized that the ages between 10 and 14 represent a critical period in shaping future career preferences (Bennett & Hogarth, 2009). This stage of development is particularly significant in terms of students' engagement with science, technology, engineering, and mathematics disciplines. As such, there is a pressing need to examine middle school students' perceptions and attitudes towards STEM disciplines, as well as their experiences with performance-based science activities. For this study, middle school students were purposively selected as participants to explore these ideas more comprehensively. Existing literature indicates that students' interest in science tends to decline with age (van Tujil et al., 2016), and that this decline is often influenced by gender differences (Fouad et al., 2010; Kahle et al., 1993). Thus, the current research seeks to address these trends by investigating how middle school students' attitudes toward STEM evolve over time and how gender may impact their engagement and career aspirations in STEM fields. For this reason, the aim of this study is to explore middle school students' perceptions on performance-based science activities according to their grade and gender. Considering the aim these research questions posed:

1. How do middle school students' attitudes toward performance-based science activities vary across different grade levels?
2. How do genders influence their interest in STEM-related careers toward performance-based science activities?

Method

Research Design

This study adopted a descriptive survey design to investigate middle school students' perceptions of performance-based science activities and their attitudes toward STEM careers. As defined by Creswell and Poth (2016), descriptive survey designs are commonly used in educational research to explore the perceptions, attitudes, interests, or abilities of a particular group. In this research, both the case study and relational survey models—subtypes of descriptive survey design—were employed. The case study approach enabled in-depth exploration within a specific group to draw generalizable insights, while the relational screening model aimed to identify the presence and strength of relationships between variables, specifically students' gender and grade level (Karasar, 2006).

Participants

The sample of this study was middle school students (from 5th to 8th grade) from a city in the Marmara region of the Turkey in the 2022-2023 academic semester. The city and schools are purposively selected since it was easy to access participants. The participants were selected by purposively sampling method; by considering easy access to participants

(Büyüköztürk et al., 2015). Accordingly total 226 middle school students (121 female, 105 male) were participated to this study. Table 1. Demonstrated demographic information about participants of the study.

Table 1

Demographic Information about Participants

	Female	Male	Total
5th Grade	40	28	68
6th Grade	32	25	57
7th Grade	22	27	49
8th Grade	27	25	52
Total	121	105	226

Ethical Committee Decision

Ethical approval for conducting the study was obtained from the Ethics Committee of Çanakkale Onsekiz Mart University on 20.10.2022, decision number 17/09.

Data Collection & Analysis

Data collection tool of this research is "Performance-based Science Education Activities" form which is developed and implemented by Villanueva Baselga et al. (2022). This form is translated into Turkish separately by the authors and then they came together and agreed on all questions of the form. During the validity phase of the form, the opinions of three faculty members who are experts in the field of science education were taken. This form consists of 27 questions including demographic, 5-Likert scale, multiple choice and open-ended short answer questions. Before data collection permission for conducting the research was obtained from the Turkish Ministry of National Education (MoNE). Subsequently, school principals were informed, and their approval was secured for the implementation phase. Additionally, informed consent forms were distributed to parents, and their written consent was obtained prior to students' participation in the study. Finally, the form was implemented by students at their schools. As a result of the reliability study, the reliability coefficient of the form is calculated and found ,87.

For data analysis all data collected from middle school students' is transcript for data analysis. In this study, a deductive thematic analysis approach was adopted to analyze the open-ended responses. The themes were determined in advance based on the conceptual framework of performance-based science education activities adapted from Villanueva Baselga et al. (2022). The coding process was conducted using a structured coding scheme aligned with these predefined themes such as "I want to be an engineer like my father" is coded under engineering is a male job and "Nurse is a good job for female" is coded under nurse is a female job. To ensure reliability, the inter-coder agreement was calculated after an initial round of coding. The two researchers discussed discrepancies and reached consensus through iterative review and refinement of the coding scheme. The intercoder reliability was calculated using percentage agreement and reached over 90,2% according to Miles & Huberman (1994), which is considered acceptable.

Findings

Results of this study is analyzed in two stages including grade and gender. The first is related to middle school students' perceptions related to their grade. In this analysis, middle school students' career choice for future is examined firstly. It was shown that less people

wanted to select STEM related careers for their future. Then it is asked to scientists' names (who lived in the past but also still alive scientists). Table 2 showed distribution of statements for scientists and some example names written by middle school students.

Table 2

Distribution of Statements in Different Scientists Names among Grades

	Total Statements	Different Scientist Names	Example Names
5th Grade	173	11	Einstein, Newton, Edison, ...
6th Grade	196	16	Einstein, Marie Curie, Graham Bell, ...
7th Grade	215	24	Einstein, Uğur Şahin, Aziz Sancar, ...
8th Grade	221	26	Einstein, Canan Dağdeviren, İlber Ortaylı, ...

Table 2 presents the distribution of middle school students' knowledge of scientists across different grades. According to Table 2, there is a significant increase in both the number of scientists mentioned and the diversity of scientists named as students' progress from the fifth to the eighth grade. The table reveals that fifth-grade students collectively named a total of 173 scientists, which equates to an average of fewer than three scientists per student. By contrast, eighth-grade students named a total of 221 scientists, averaging over four scientists per student. Moreover, the diversity of scientists increased markedly with grade level. Fifth-grade students identified only 11 different scientists' names, while eighth-grade students recognized 26 different scientist names.

A key observation from the data is that, as students advance through middle school, they not only mention a greater number of scientists but also expand the range of scientists they recognize. For instance, while fifth-grade students predominantly named historical figures in science such as Einstein, Newton, and Edison, eighth grade students demonstrated a broader awareness of contemporary and diverse scientists' names.

By the eighth grade, students began to recognize female scientists, including Marie Curie and Canan Dağdeviren, as well as living scientists such as Uğur Şahin and Aziz Sancar. Additionally, eighth-grade students identified scientists outside of the realm of positive sciences, including those from fields such as archaeology and history, exemplified by figures like İlber Ortaylı.

Gender-Based Differences in Perceptions of Professions

Further analysis was conducted to examine middle school students' perceptions of scientists and career choices according to gender. Students also evaluated six STEM-related professions—astronomer, engineer, veterinarian, theoretical physicist, nurse, and programmer—and categorized each as a male job, a female job, or gender-neutral. Preliminary findings indicate that female students were more likely to mention female scientists, with names such as Marie Curie and Canan Dağdeviren frequently cited by girls.

Female students may be more inclined to identify with and be inspired by female scientists, which highlights the potential impact of increasing visibility of women in STEM on students' career aspirations. When examining students' career preferences, the data revealed that only a small proportion of both boys and girls expressed an interest in pursuing STEM-related careers, including roles such as scientists, engineers, or academics. The limited interest

in STEM careers may be influenced by a variety of factors, including gender stereotypes, societal expectations, and a lack of confidence in their scientific abilities.

Table 3

Middle School Students' Perceptions of Professions by Gender

Careers	Girls Female Job	Girls Male Job	Girls No Gender	Boys Female Job	Boys Male Job	Boys No Gender
Astronomers	12 (9.9)	35 (28.9)	74 (61.2)	8 (7.6)	40 (38.1)	57 (54.3)
Engineer	5 (4.1)	92 (76.0)	24 (19.8)	3 (2.9)	88 (83.8)	14 (13.3)
Veterinarian	30 (24.8)	27 (22.3)	64 (52.9)	18 (17.1)	30 (28.6)	57 (54.3)
Theoretical Physicist	10 (8.3)	40 (33.1)	71 (58.7)	6 (5.7)	50 (47.6)	49 (46.7)
Nurse	95 (78.5)	5 (4.1)	21 (17.4)	84 (80.0)	4 (3.8)	17 (16.2)
Programmer	7 (5.8)	56 (46.3)	58 (47.9)	5 (4.8)	60 (57.1)	40 (38.1)

Table 2 presents middle school students' perceptions of gender roles in six different professions: astronomer, engineer, veterinarian, theoretical physicist, nurse, and programmer. The data reveal strong gender stereotypes, particularly regarding engineering and nursing. A majority of both boys (83.8%) and girls (76.0%) consider engineering to be a male-dominated field, while nursing is overwhelmingly perceived as a female profession by 78.5% of girls and 80.0% of boys. Interestingly, girls are more likely than boys to believe that professions have no gender, with higher percentages selecting the “no gender” category for each profession. For example, 61.2% of girls and 54.3% of boys see astronomy as a gender-neutral field, while 47.9% of girls and 38.1% of boys believe the same for programming. These findings suggest that while gender biases persist in career perceptions, some students, particularly girls—are more open to breaking traditional stereotypes. Increasing awareness and representation of diverse role models in STEM and other fields may help reduce these biases over time.

To further explore students' perceptions of gender and careers, students were asked to evaluate six different professions—astronomer, engineer, veterinarian, theoretical physicist, nurse, and programmer—and to indicate whether they believed these jobs were best suited for men, women, or both. Preliminary analysis revealed that both boys and girls largely considered engineering to be a male-dominated profession, while nursing was predominantly viewed as a female-dominated occupation. These gendered perceptions of careers are deeply rooted in societal stereotypes that associate certain jobs with specific genders. However, it is worth noting that a higher percentage of girls than boys believed that jobs have no inherent gender, suggesting that girls may be more open to the idea of breaking traditional gender norms in career choices. An additional finding from the study was that some female students expressed dissatisfaction with their limited knowledge of female scientists. This sentiment reflects the broader issue of underrepresentation of women in STEM, both in educational contexts and in the media. The scarcity of female role models in science can have a profound impact on young girls' aspirations, potentially discouraging them from pursuing careers in STEM fields. Addressing this issue requires a concerted effort to increase the visibility of female scientists in educational materials, media representations, and classroom discussions. By doing so, educators can help challenge the traditional gender norms that have historically marginalized women in STEM and encourage more girls to consider STEM careers as viable and rewarding options.

In conclusion, the findings of this study highlight several important trends in middle school students' perceptions of scientists and STEM careers. As students' progress through middle school, their knowledge of scientists expands, both in terms of the number of scientists they recognize and the diversity of disciplines they acknowledge. However, gender stereotypes regarding careers persist, particularly regarding professions such as engineering and nursing. The data also reveal that girls are more likely to identify female scientists and are more open to the idea that jobs should not be restricted by gender. Nevertheless, the underrepresentation of female scientists in students' knowledge base points to the need for greater efforts to promote gender diversity in science education. Through targeted interventions, such as increasing the visibility of female scientists and challenging traditional gender roles in career aspirations, educators can help foster a more inclusive environment that encourages all students, regardless of gender, to pursue their interests in STEM.

Discussion and Implications

The aim of this research was to investigate middle school students' perceptions of performance-based science activities and their attitudes toward STEM-related careers. A total of 226 students participated in the study. One notable trend in the data is that, across all grade levels, the most frequently mentioned scientists were predominantly male. This reflects a well-documented issue in science education, where male scientists are often emphasized in curricula and popular media, while female scientists remain underrepresented. However, the increasing recognition of female scientists by higher-grade students suggests a gradual awareness of gender diversity in science, providing valuable insights into how students' perceptions of science and STEM evolve during this critical developmental period. Preliminary analyses revealed a decline in students' interest in science and STEM-related careers as they progress through middle school. Additionally, the data indicated that fewer girls expressed a desire to pursue STEM careers in the future. These findings align with existing literature, which suggests that, despite enjoying science, many middle school students lack the self-confidence to envision themselves as scientists (Regan & DeWitt, 2014). One key finding of the study was that most middle school students acknowledge the importance of science but do not see themselves working in STEM fields. This result supports the findings of Archer et al. (2010), which indicated that students often perceive science as valuable but not as a suitable career choice.

This disconnection between students' recognition of the value of science and their reluctance to pursue it as a career is further reinforced by the stereotype that scientists are exceptionally intelligent and successful individuals. Many students in this study expressed the belief that scientists are highly gifted, reinforcing the notion that science is a field reserved for a select few. Such stereotypes create psychological barriers that prevent students, particularly those who do not perceive themselves as academically exceptional, from aspiring to STEM careers (Van Tuijl et al., 2016).

Gender differences in students' perceptions of scientists and STEM careers were also consistent with previous research. Many students in this study viewed nursing as a female-dominated profession, while engineering was perceived as a male-dominated field. This gendered division of labor mirrors societal stereotypes and reflects broader issues of underrepresentation of women in STEM careers. The lack of female role models in science and

engineering, combined with traditional gender roles, likely contributes to these perceptions (Archer et al., 2010; Blickenstaff, 2005). The persistence of these gender stereotypes not only discourages girls from pursuing STEM careers but also reinforces cultural norms that perpetuate gender disparities in these fields. The findings of this research have important implications for understanding middle school students' perceptions of scientists, their attitudes toward science, and their future career aspirations in STEM. One significant implication is the potential role that performance-based science activities could play in reshaping students' attitudes and perceptions (Van Tuijl et al., 2016). Performance-based activities, which emphasize hands-on, inquiry-driven learning experiences, have the potential to demystify science and make it more accessible. By engaging in these activities, students can develop a more realistic and personalized understanding of what it means to be a scientist, increasing their confidence and interest in STEM careers (Dost, 2024).

Research has shown that students' attitudes toward science and STEM are shaped by a combination of personal experiences, societal stereotypes, and a lack of relatable role models (Camilli & Hira, 2019). However, these attitudes are not fixed, and educational interventions, such as performance-based science activities, could play a crucial role in shifting students' perceptions. By providing opportunities for students to engage in science in a more interactive and relevant manner, educators can help them develop a stronger sense of ownership over their learning and foster a more positive association with science (Yeşilkaya et al., 2023). This, in turn, may lead to increased motivation and interest in STEM-related fields, particularly for students who previously felt disconnected from or intimidated by science (Shen et al., 2016). Moreover, performance-based science activities have the potential to challenge and disrupt gender stereotypes that influence career aspirations. By creating a learning environment that is inclusive and supportive of all students, regardless of gender, educators can help combat the traditional gender roles that often dissuade girls from pursuing STEM careers (Camilli & Hira, 2019).

Exposure to female scientists and engineers, as well as opportunities to work collaboratively on real-world scientific problems, can provide girls with the role models and experiences necessary to envision themselves in STEM professions (Yeşilkaya et al., 2023). Addressing gender disparities in STEM requires not only curricular changes but also a concerted effort to challenge societal norms and provide students with diverse examples of success in science and engineering. This research sheds light on middle school students' perceptions of science, scientists, and STEM careers. The findings highlight the importance of performance-based science activities as a potential method for increasing students' engagement with and interest in STEM. While the study reveals a general decline in interest in science across grade levels and a significant gender gap in STEM career aspirations, it also suggests that these trends are not irreversible. By implementing strategies that foster a more inclusive and engaging science education experience, educators can help shift students' attitudes and increase the likelihood that they will pursue careers in STEM.

Ultimately, these efforts are essential for addressing the underrepresentation of women in STEM and ensuring that all students could succeed in these critical fields (Blackley & Howell, 2015). The findings emphasize the ongoing gender inequalities that shape students' perceptions of scientists and STEM careers. The fact that both boys and girls are more familiar with male scientists and continue to associate certain careers with specific genders underscores the need for educational interventions that promote greater gender equity in science education. Additionally, the study highlights the need to address students' self-

perceptions of their abilities in science, particularly the belief that science is reserved for a select few "gifted" individuals (Jessani, 2015). Encouraging a broader, more inclusive view of who can succeed in STEM fields is critical for fostering a more diverse and motivated future STEM workforce. Furthermore, the results underscore the potential benefits of performance-based science education in promoting positive attitudes toward science. Although students recognize the importance of science, the disconnect between their appreciation of science and their belief in their own ability to engage with it suggests that traditional methods of science instruction may not be effectively bridging this gap. Performance-based activities, which emphasize hands-on, inquiry-driven learning, may offer a more engaging and accessible approach to science education (Littledyke, 2008).

This study contributes to existing literature by providing empirical evidence on how performance-based science activities intersect with students' perceptions of STEM careers, gender stereotypes, and self-efficacy beliefs during the critical middle school years. While previous research has highlighted the importance of early STEM engagement, this study extends the literature by examining how hands-on, inquiry-driven learning experiences can shape students' attitudes toward science in more inclusive and empowering ways. The findings offer nuanced insights into how gendered perceptions of scientists persist among middle school students and how performance-based approaches may serve as a strategic tool to mitigate these stereotypes. By focusing on students' actual experiences with science activities, this research advances our understanding of how educational practices can be transformed to foster greater interest, confidence, and gender equity in STEM fields.

Conclusion

This study provides valuable insights into middle school students' attitudes toward performance-based science activities and STEM careers. The findings highlight ongoing challenges related to gender inequalities, career aspirations, and self-perceptions of scientific ability among students. These challenges have significant implications for the future of STEM education and workforce development, emphasizing the need for targeted interventions that address both gender stereotypes and students' beliefs about their own potential. By fostering a more inclusive and supportive environment for science education, it may be possible to reverse the current decline in STEM participation and cultivate a new generation of scientists, engineers, and innovators who reflect the diversity of society.

Suggestions for Practice

1. Integrate diverse role models into science lessons. Teachers can incorporate examples of both female and male scientists from various cultural backgrounds into performance-based activities to challenge gender stereotypes and broaden students' perceptions of who can be a scientist.
2. Provide professional development for teachers and administrators. School leaders should offer training that equips educators with strategies to identify and address gender bias, promote equity in the classroom, and support students' confidence in STEM subjects.

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Statement of Researchers

Researchers' contribution rate statement: The first author was responsible for 60% (statement of the literature, data collection, findings and suggestions for practice), the second author was responsible for remaining 40% (methods and discussion)

Conflict of Interest: The researchers declare no personal conflicts of interest related to the research.

Funding, Support and thanks: This study was supported by Canakkale Onsekiz Mart University Scientific Research Projects number 4258.

Ethical Standards

Ethical approval for conducting the study was obtained from the Ethics Committee of Çanakkale Onsekiz Mart University on 20.10.2022, decision number 17/09. Also, all participants participated voluntarily and both their parents' written consents were obtained.