



STEM Skills Self-Efficacy and Motivation: Analysis of Opportunities and Challenges in Elementary Level

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ABSTRACT

Purpose - The study examines the self-efficacy in STEM skills and the motivation of elementary school student in science learning on the theme of sustainable cities, highlighting gender and regional differences in East Kalimantan to understand the opportunities, challenges, and their implications for inclusive and sustainable learning.

Methodology - This study employed a mixed-methods approach with a cross-sectional, explanatory, sequential design, involving 450 students and 8 teachers from elementary schools in Kutai Kartanegara, Samarinda, and Balikpapan. Data were collected through validated self-efficacy and motivation questionnaires and teacher interviews, then analyzed descriptively (SPSS) and thematically using joint display integration to illustrate students' self-efficacy and motivation dynamics across gender and regional contexts. Qualitative findings complemented the quantitative results by capturing teachers' perspectives on instructional practices and classroom barriers to STEM implementation.

Findings - Findings reveal that while students generally demonstrate high levels of self-efficacy and motivation, there is a subtle gap: female students exhibit lower confidence in engineering tasks, mathematical self-efficacy remains moderate across all genders, and little disparity is evident between urban and non-urban learners. Students are highly motivated by activities that are enjoyable, challenging, and hands-on; however, traditional teaching methods and limited adoption of innovative STEM approaches – including project-based and game-based learning – constrain these benefits.

Contribution - When supported by differentiated and inclusive learning environments, such approaches enhance self-efficacy, foster critical thinking, and increase engagement. These findings underscore the need for pedagogical transformation in elementary STEM education to address gender and regional gaps while maximizing students' confidence, motivation, and preparedness for future academic and career pathways.

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INTRODUCTION

The acceleration of technological and industrial advancement has driven a significant increase in demand for a professional workforce equipped with STEM (Science, Technology, Engineering, and Mathematics) competencies. Consequently, all countries require broader, more coordinated instructional strategies in STEM across all levels of education, from elementary schools to universities (Gok, 2021). Introducing STEM at an early age is crucial because the foundation of STEM interests and skills is laid in elementary school, where children begin to observe, explore, and manipulate their environment. This exploration fosters inquiry and causal reasoning, which are essential for maintaining long-term interest. (López & Cabello, 2022). Access to early STEM experiences also empowers young learners and is correlated with a greater interest in pursuing STEM-related careers in the future (Amsbary, J., Yang, H.-W., Sam, A., Lim, C.-I., & Vinh, 2023; Waters, 2022).

Various initiatives to strengthen the STEM ecosystem position two psychological constructs as key determinants of learning success and career sustainability, namely STEM self-efficacy and motivation. This constitutes a fundamental step in understanding the challenges and opportunities at the elementary school level. Self-efficacy, defined as an individual's belief in their capability to succeed in specific tasks, has been widely recognized as a critical factor influencing academic achievement and engagement in STEM education (Awaludin et al., 2024; Rivera & Li, 2020). According to Bandura, enhancing self-efficacy is closely linked to positive learning experiences, which directly impact students' achievement and motivation to engage more deeply in STEM learning (Samsudin et al., 2020).

Students with high self-efficacy in STEM subjects tend to be more motivated to participate in STEM learning activities and extracurricular programs (Luo et al., 2021; Rivera & Li, 2020). This is particularly important, given that the success of STEM education implementation at the elementary school level depends on students' ability to recognize the relevance and future career potential associated with these disciplines. Research has shown that students' perceptions of the value of STEM are positively correlated with their interest in pursuing STEM-related careers and their motivation to learn (Sheng et al., 2023).

Meta-analytic evidence and systematic reviews also indicate that active learning interventions and authentic experiences (e.g., hands-on activities, projects, laboratory practices) can enhance self-efficacy (Luzin et al., 2024) and motivation (Hermiati et al., 2024; Lusidawaty et al., 2020), particularly when designed to maximize progressive mastery experiences and provide constructive feedback (Gusteti et al., 2024). Students' active engagement in project-based tasks allows them to experience mastery, a key component of self-efficacy as described by Bandura, which reflects real-world problem solving and enhances their confidence in their abilities, thereby motivating them to pursue further learning challenges. Moreover, professional development for STEM teachers plays a critical role in fostering teaching self-efficacy, which in turn influences students' motivation and achievement (Hu et al., 2022; Oje et al., 2021).

From another perspective, challenges remain, particularly those related to gender. Gender issues continue to function as a discriminatory factor within the context of STEM education. Previous studies have indicated that women often exhibit lower levels of self-efficacy in science and technology, which contributes to their underrepresentation in STEM fields (Chan, 2022; Fuller et al., 2023). This phenomenon is largely driven by social stereotypes that perceive STEM as a domain more suitable for men. To foster an inclusive learning environment, educational policies need to be designed to cultivate confidence.

Although STEM foundations in elementary education are critical, significant research gaps remain. There is still a lack of specific, in-depth studies on the dynamics of STEM self-efficacy and motivation among elementary school students, particularly with respect to gender and regional differences. A comprehensive analysis is therefore needed to understand better the opportunities and challenges in developing these two psychological constructs. Accordingly, this study aims to bridge that gap. We seek to make a significant contribution to the design of more effective pedagogical strategies or learning media that can foster students' self-efficacy and motivation from an early age. More specifically, this study has two primary objectives: (1) to analyze differences in STEM skills self-efficacy and motivation among elementary school students based on gender and region, and (2) to identify opportunities and challenges in developing elementary students' self-efficacy and motivation toward STEM learning.

METHODOLOGY

Research Design

This research began with the preparation stage, during which four aspects were prepared: conceptual definitions of motivation and self-efficacy, adaptation, the measurement instrument, and the sample determination. A literature review was conducted to establish a clear conceptual definition of self-efficacy and motivation in STEM learning. This study employed an explanatory sequential mixed-methods design (Mackiewicz, 2018), in which quantitative data were collected and analyzed first, followed by qualitative data to explain the quantitative findings. The quantitative phase used a cross-sectional survey to assess students' STEM skills self-efficacy (SE) and motivation (MO). The results of the quantitative analysis were then used to identify specific patterns and groups of interest, which guided the selection of participants and the development of open-ended questions for the qualitative phase. Subsequently, qualitative data were collected through open-ended questionnaires and teacher interviews to provide deeper explanations of the quantitative results. The integration of quantitative and qualitative findings was conducted using a joint display approach to generate meta-inferences beyond separate analyses (Fetters et al., 2013).

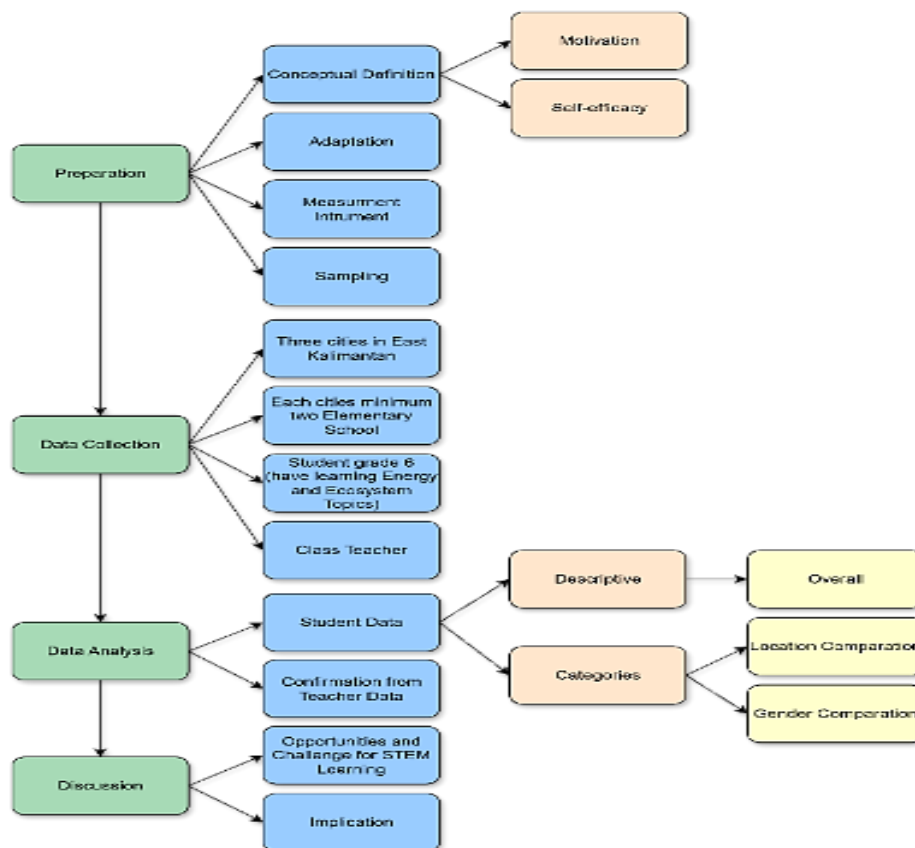


Figure 1. Research Design

This research start with: (1) Preparation: concept definition, instrument adaptation and testing, and simple determination, (2) Data Collection: administering questionnaires and conducting teacher interviews in three cities (Kutai Kartanegara, Samarinda, and Balikpapan with sixth-grade students), (3) Data Analysis: descriptive analysis based on general categories, regions, and gender), and (3) Discussion: interpreting result to identify opportunities, challenges, and implications for STEM learning in elementary schools).

Participant

Data were collected from four regions in East Kalimantan, namely Kutai Kartanegara Regency, Samarinda City, and Balikpapan City. A multistage cluster sampling technique was employed in this study. In the first stage, the regions were purposively selected to represent different geographical areas in East Kalimantan and to enable comparative analysis based on region and gender. In the second stage, elementary

schools within each region were selected as clusters. From each selected school, all fifth-grade students who had studied energy and ecosystem science were included as participants. The selection of fifth-grade students was based on their prior exposure to fundamental STEM-related science concepts, making them suitable for assessing STEM self-efficacy and motivation. A total of 450 students participated in this study. The demographic profile of the participants is presented in Table 1, which shows the distribution of students based on gender and region.

Table 1: Demographic profile of the participants

Region	Male	Female	Total
Kutai Kartanegara	43	57	100
Samarinda	77	80	157
Balikpapan	98	95	193
Total	218	232	450

As shown in Table 1, the participants consisted of 218 male and 232 female students. The distribution across regions indicates a relatively balanced representation, supporting comparative analysis based on gender and regional differences. In addition to the students, eight classroom teachers (one from each school) were involved to provide qualitative data through interviews.

Data Collection

Data collection was conducted directly in classrooms, using printed questionnaires distributed to students and teachers. Each student was asked to complete the self-efficacy (SE) and motivation (MO) questionnaires independently, with assistance from the researcher and classroom teachers to ensure proper understanding of each question item. The completion process was conducted in a regular learning environment so that students would feel comfortable and could provide honest answers based on their experiences in STEM learning. In addition, in-depth interviews were conducted with eight classroom teachers to enrich the quantitative findings. These interviews focused on teachers' perspectives on students' motivation and self-efficacy in STEM learning activities, as well as the factors influencing their development in the elementary school environment. This dual approach allowed the researchers to gain a more comprehensive understanding of the context and dynamics of learning in the field.

Instrument

The Self-Efficacy (SE) and Motivation (MO) instruments were developed based on specific theoretical dimensions. The SE instrument encompassed three main domains: (1) Science, including conceptual problem-solving, exploration of science topics, data collection, scientific prediction, and design-oriented research; (2) Engineering and Technology, including problem-solving suggestions, concept-based design, designing scientific prototypes, prototype testing, and information gathering; and (3) Mathematics, including calculating scientific mathematics, drawing data-driven conclusions, applying basic mathematics, and visual data representation. Meanwhile, the MO instrument consisted of three dimensions: interest, understanding, and usefulness.

Both instruments were tested for internal consistency reliability using Cronbach's Alpha through a pilot study prior to the main data collection. The analysis conducted using SPSS indicated that the SE instrument demonstrated good reliability, with a Cronbach's Alpha coefficient of 0.819. Meanwhile, the MO instrument yielded a Cronbach's Alpha value of 0.617, indicating moderate internal consistency. Although this value is slightly below the commonly recommended threshold of 0.70, it is still considered acceptable for exploratory research. Therefore, both instruments were deemed sufficiently reliable for use in this study.

Data Analysis

Quantitative data were analyzed using SPSS to produce descriptive statistics differentiated by gender and region. Qualitative data from teacher interviews were thematically coded to identify factors influencing

students' self-efficacy and motivation. Both types of data were then integrated through a joint display approach to obtain a more comprehensive understanding of the research findings.

FINDINGS

Gender Comparison

Descriptive statistical analyses were conducted to compare students' STEM self-efficacy (SE) and motivation (MO) across gender groups. The mean scores, standard errors, and 95% confidence intervals for each group are presented in Table 2.

Table 2. Mean Scores of STEM Skills Self-Efficacy and Motivation Based on Gender

Gender	Self-efficacy		Motivation	
	Mean	Std. Error	Mean	Std. Error
Female	39.613	0.404	11.864	0.110
Male	40.382	0.432	12.080	0.120

The results presented in Table 2 indicate slight differences in STEM self-efficacy (SE) and motivation (MO) between male and female students. Male students show marginally higher mean scores in both self-efficacy (M = 40.382) and motivation (M = 12.080) compared to female students (SE: M = 39.613; MO: M = 11.864). However, the magnitude of these differences is relatively small. This is further supported by the overlapping 95% confidence intervals for both variables, suggesting that the differences between male and female students may not be substantial. These findings imply that although male students tend to report slightly higher confidence and motivation in STEM, both genders demonstrate relatively comparable levels at the elementary school level. Further analysis of SE components reveals that, although the differences are not substantial, female students scored higher in mathematics mastery, while male students outperformed females in science, engineering, and technology (Table 3).

Table 3. Summary of Elementary School Students' Self-Efficacy by Gender

Comp	Question Items	Male				Female			
		M	SD	%	Category	M	SD	%	Category
SCIENCE	Conceptual Problem-Solving	2.977	0.734	74	High	2.797	0.865	70	Moderate
	Explore Science Topics	3.110	0.697	78	High	2.935	0.839	73	High
	Data Collection	3.055	0.742	76	High	2.948	0.777	74	High
	Scientific Prediction	2.679	0.819	67	Moderate	2.741	0.837	69	Moderate
	Design-Oriented Research	2.904	0.812	73	High	2.832	0.907	71	High
	Average Science	2.945	0.761	74	High	2.851	0.845	71	High
	Problem-Solving Suggestion	2.922	0.808	73	High	2.953	0.757	74	High
ENGINEERING & TECHNOLOGY	Concept-Based Design	2.890	0.862	72	High	2.767	0.788	69	Moderate
	Designing a Scientific Prototype	2.913	0.778	73	High	2.849	0.783	71	High
	Prototype Testing	3.032	0.708	76	High	2.866	0.834	72	High
	Information Gathering	3.000	0.774	75	High	3.047	0.791	76	High

Comp	Question Items	Male				Female			
		M	SD	%	Category	M	SD	%	Category
MATHEMATICS	Average Engineering & Technology	2.951	0.786	74	High	2.897	0.791	72	High
	Calculate Scientific Math	2.541	0.864	64	Moderate	2.621	0.839	66	Moderate
	Data-Driven Conclusion	2.839	0.742	71	High	2.897	0.737	72	High
	Basic Math Application	2.596	0.917	65	Moderate	2.616	0.824	65	Moderate
	Visual Data Representation	2.954	0.779	74	High	2.931	0.792	73	High
	Average Mathematics	2.733	0.825	68	Moderate	2.766	0.798	69	Moderate

In the science component, the lowest-rated item for both male and female students was the ability to predict outcomes based on scientific concepts when conducting measurements. Predictive ability is an element of critical thinking skills and one of the Science Process Skills. Meanwhile, in the engineering and technology components, the lowest scores were obtained for the indicator 'applying scientific concepts to design simple tools or projects to solve problems.' In this regard, female students scored below 70% in Self-Efficacy (SE). Although this percentage still falls within the moderate category, a considerable disparity was observed between female and male students. Psychological factors may influence this gap, as female students tend to interact differently with activities perceived as 'masculine.' Several studies have demonstrated that females' emotional and psychological experiences, such as higher levels of anxiety toward experimental tasks, may hinder their confidence in assembling or conducting experiments (Elizar & Darmawan, 2019). This issue is critical, as high self-efficacy is a key factor in developing creative thinking skills, which are essential for designing innovative projects (Levinta et al., 2024).

The gender comparison also examined students' motivation toward science learning at the elementary school level across the three regions included in the sample. Based on the mean scores presented in Table 3, the average motivation levels of female and male students did not differ substantially. However, as shown in Table 4, the mean motivation score of male students reached 80%, which was slightly higher than that of female students in the context of elementary science learning."

Table 4. Summary of Students' Motivation by Region and Gender

Region	Gender	Motivation Aspect			Average Motivation Based on Region
		Interest	Understanding	Usefulness	
Kutai Kartanegara	Female	74%	76%	83%	78%
	Male	72%	75%	87%	
Samarinda	Female	76%	75%	89%	81%
	Male	81%	77%	86%	
Balikpapan	Female	75%	76%	89%	81%
	Male	79%	78%	90%	
Motivation of Female Students		75%	76%	87%	79%
Motivation of Male Students		77%	77%	87%	80%

Multiple factors, including gender, can influence students' motivation in science learning. Research indicates slight differences in learning motivation between male and female students, which instructional approaches and classroom environments may shape. Hermiati et al. investigated students' learning motivation in science across three schools. They found that gender differences influenced how students interacted with scientific content, with male students demonstrating greater motivation for active participation than their female counterparts (Hermiati et al., 2024).

Based on the factor of interest within the motivation variable, most students reported enjoying science because the subject matter was engaging, contextual, and frequently encountered in everyday life, as well as because of teachers' engaging instructional approaches. On the other hand, students also indicated aspects that made science less appealing, such as the perception that it was difficult, that the material was monotonous, and that the content did not seem connected to everyday concepts.

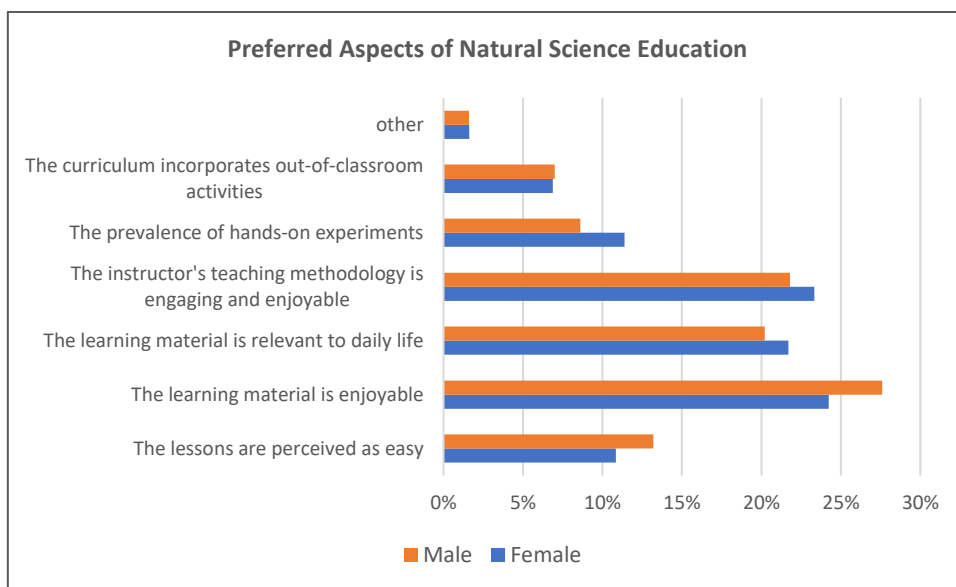


Figure 2. Factors Influencing Students' Interest in Science

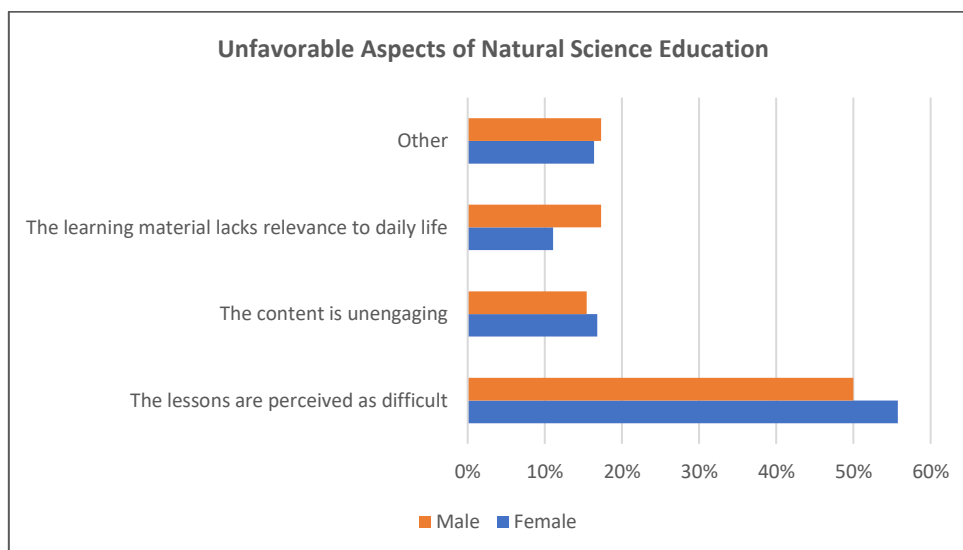


Figure 3. Factors Contributing to Students' Disinterest in Science

In terms of comprehension, male students reported a slightly higher level (77%) than female students (76%), as shown in Table 4. Furthermore, a majority of students agreed that science learning presents certain difficulties, with 345 out of 450 respondents indicating that some science materials are challenging. The difficulties students had in understanding science were attributed to the content being hard to remember, the large volume of material, and learning activities that were primarily focused on completing assignments.

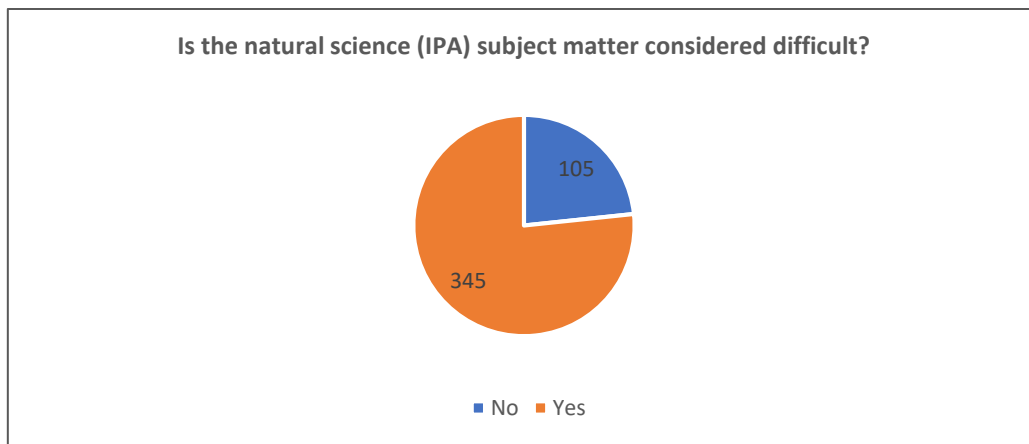


Figure 4. Students' Perceptions of Figure Difficulties in Science Learning

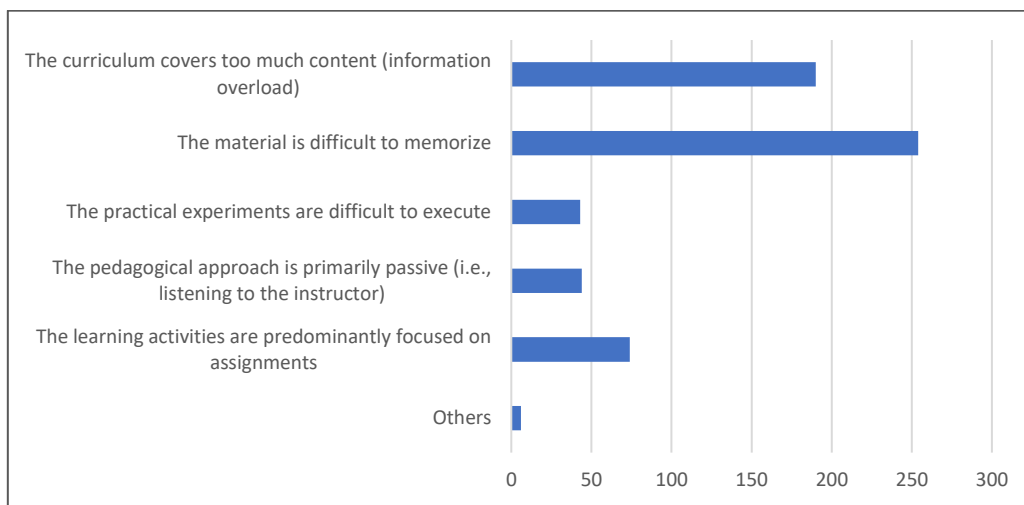


Figure 5. Factors Making Science Learning Difficult for Students

In the sub-component of motivation, namely perceived usefulness, both male and female students agreed that science is important because it is an essential subject closely related to human daily life. They also recognized that the benefits of learning science include broadening their knowledge and understanding of the human body and its maintenance, the natural environment, and the importance of environmental preservation. Furthermore, students acknowledged that the usefulness of science learning lies in its relevance to their future and its alignment with their aspirations.

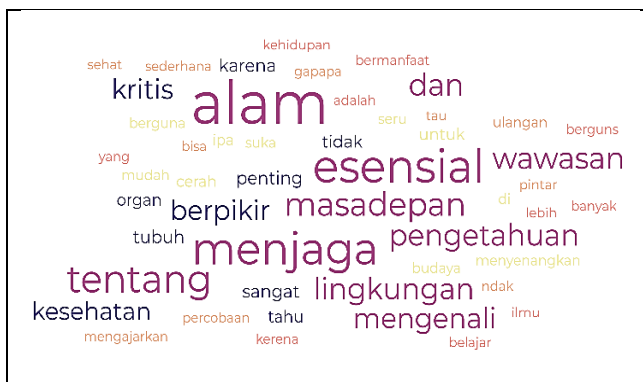


Figure 6. Perceived Usefulness of Science According to Male Students

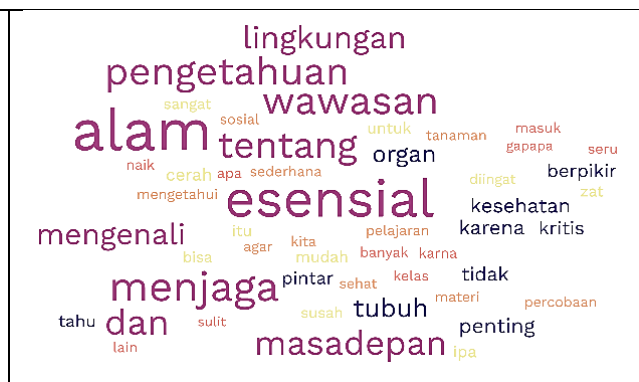


Figure 7. Perceived Usefulness of Science According to Female Students

Comparative Location

Based on the analysis of Self-Efficacy (SE) data across three regions—Kutai Kartanegara Regency, Samarinda City, and Balikpapan City—it was found that the SE levels did not differ substantially among the regions. However, Kutai Kartanegara Regency recorded the lowest mean SE among the three cities, as shown in Table 5.

Table 5. Self-Efficacy & Motivation Mean Based on Location

Region	Mean	Std. Error	Mean	Std. Error
Kutai Kartanegara	39.166	0.607	11.655	0.170
Samarinda	40.492	0.481	12.106	0.132
Balikpapan	40.335	0.432	12.155	0.114

Based on the analysis presented in Table 4, the levels of students' self-efficacy (SE) across the three regions, Kutai Kartanegara, Samarinda, and Balikpapan, show relatively small variations. Samarinda recorded the highest mean SE score ($M = 40.492$), followed closely by Balikpapan ($M = 40.335$), while Kutai Kartanegara showed the lowest mean ($M = 39.166$). A similar pattern is observed in motivation (MO), where Balikpapan ($M = 12.155$) and Samarinda ($M = 12.106$) show higher scores than Kutai Kartanegara ($M = 11.655$).

Despite these differences in mean scores, the overlapping 95% confidence intervals across the three regions for both SE and MO indicate that the variations are not statistically substantial. This suggests that students' self-efficacy and motivation in STEM are relatively comparable across regions. However, there is a consistent tendency for students in Samarinda and Balikpapan to report slightly higher levels than those in Kutai Kartanegara. This pattern may reflect differences in learning environments or access to educational resources, with students in more urbanized areas demonstrating marginally higher confidence and motivation in STEM-related learning. When analyzed by individual SE components across the three locations, the mathematics component received the lowest score.

Table 6. Self-Efficacy Components based on Different Locations

Component	Descriptive Statistical	Kukar	Samarinda	Balikpapan
Science	Mean	2,818	2,931	2,909
	SD	0,771	0,631	0,845
	Persentase	70%	73%	73%
Engineering & Technology	Mean	2,834	2,950	2,947
	SD	0,801	0,715	0,836
	Persentase	71%	74%	74%
Mathematics	Mean	2,693	2,777	2,758
	SD	0,832	0,716	0,870
	Persentase	67%	69%	69%

In the mathematics self-efficacy component, students across the three regions demonstrated moderate levels of self-efficacy. This moderate level was reflected in two aspects: first, students perceived their abilities as limited to simple arithmetic operations related to scientific concepts; second, they lacked confidence in using mathematics as a reliable tool for solving scientific problems. Mathematics anxiety uniquely shaped students' perceptions and beliefs about their mathematical abilities, further exacerbating this self-efficacy gap. Research has shown that students with higher levels of mathematics anxiety tend to report lower self-efficacy in mathematics, as evidenced by the findings of Magnate et al., where a clear negative correlation was observed between mathematics anxiety and performance (Magnate & Sulatra, 2023). This relationship underscores why self-efficacy in mathematics, in particular, is perceived as lower than in other STEM disciplines, where such anxiety may be less prevalent or less impactful.

Within the motivation variable, specifically the interest sub-component, the analysis of open-ended questionnaire responses using the Word Cloud technique revealed that the majority of students across all

conducted at home or outdoors—further reinforce students' motivation to deepen their understanding of various scientific concepts (Chan, 2022). Another critical factor concerns teachers' role in fostering a classroom environment that nurtures students' curiosity. Teachers can employ activities that stimulate inquisitiveness, such as research-based projects or field explorations, to enhance student engagement. Such enjoyable and challenging learning experiences not only serve to motivate students but also deepen their understanding of the applications of science in everyday life (Alam et al., 2021).

DISCUSSION

Challenges for Self-Efficacy & Motivation in Science Learning at the Elementary Level

The analysis of self-efficacy data by gender revealed no significant differences in mean scores between male and female students. Nevertheless, variations were observed across several sub-components, with female students reporting lower confidence levels, particularly in engineering-related areas such as applying science concepts to design simple projects. This finding is consistent with previous studies indicating that individuals with higher self-efficacy are more likely to engage in activities requiring technical skills and creativity (Brandon, 2000; Rahmadani et al., 2023). The self-efficacy gap in STEM can be attributed to social expectations and stereotypes, which have historically encouraged male students to pursue science and mathematics more than their female counterparts (Alam et al., 2021; Chan, 2022). In gender studies, for instance, female students frequently demonstrate lower self-efficacy in physics, despite achieving equal or even higher academic performance than male students (Whitcomb et al., 2020). Such discrepancies necessitate targeted interventions to ensure that students' true confidence is reflected in their participation and persistence in STEM fields (Whitcomb et al., 2020). The adverse effects of gender stereotypes have been shown to undermine female students' self-belief and hinder their pursuit of STEM-related careers (Alam et al., 2021; Negara R P et al., 2024; Whitcomb et al., 2020). Therefore, this study reaffirms the importance of fostering inclusive learning environments that enhance self-efficacy for all students, with particular attention to strategies that address the barriers faced by female students in science education (Rusmiati, 2022; Salam et al., 2023).

The ability to make predictions based on scientific concepts for conducting measurements also presents a challenge for both male and female students. Prediction skills are often underdeveloped in rigid learning environments. The use of interactive teaching methods, such as inquiry-based and collaborative learning, has been shown to better facilitate students in building deeper understanding and developing critical thinking skills that are essential for prediction (Alamsyah et al., 2021; Syafi'ah et al., 2022).

Studies have shown that integrating collaborative and project-based learning methods can help foster self-efficacy among female students by enhancing participation and reducing gender bias in skill development (Masitoh & Fitriyani, 2018). Supportive environments that emphasize teamwork and shared responsibility provide low-risk learning experiences, which in turn promote greater confidence and gradual skill improvement over time (Espinosa et al., 2019). It is therefore essential for educators and policymakers to acknowledge the gender-based dynamics of self-efficacy and to design supportive learning structures that bridge self-efficacy gaps, ultimately leading to improved abilities to design tools and projects among all students (Namaziandost & Çakmak, 2020).

Student self-efficacy in the mathematical component was found to be moderate across both male and female students at the three research sites. Specifically, confidence in applying mathematical concepts to solve science-related problems and in using graphs to explain experimental results remained at a moderate level compared to other sub-components. This finding is consistent with Petronio Buaya's study, which reported that students' average self-efficacy scores fall within the moderate confidence range (Buaya, 2024). The study further emphasized that students' perceptions are significantly shaped by their social environments, including encouragement from peers, families, and educators. In this context, project-based learning provides students with opportunities to collaborate in groups, address complex problems, and apply mathematical theories to real-world situations. Consequently, students become more capable of viewing mistakes as learning opportunities, thereby enhancing their confidence in solving mathematical problems (Ahmad et al., 2023; Febri

Rafli et al., 2018), while also fostering active engagement in discussions and reflections, which are critical for the development of their mathematical representation skills (Yanti et al., 2024).

Although the majority of students reported liking science subjects, they also indicated that science materials are difficult and often perceived as unrelated to everyday life. This perception arises because several components of science lessons are frequently considered complex, requiring logical reasoning and a deep understanding of theoretical concepts (Rusnayatia et al., 2015; Sastra, 2021). Such difficulties are exacerbated when students lack a strong grasp of fundamental concepts, leading them to feel disconnected from the material being taught (Nurhanifah & Utami, 2023; C. A. Putri & Zulfadewina, 2023). Furthermore, some students reported challenges understanding how scientific concepts can be applied in real-world contexts, which, in turn, diminished their motivation to engage with the subject (Nurhanifah & Utami, 2023; Tasdik & Amelia, 2021).

Teachers' instructional strategies also contribute to students' negative perceptions of science subjects. Many teachers continue to rely on traditional approaches, such as lecture-based methods with minimal active interaction, which often results in limited student engagement. Research indicates that students are more responsive to instructional methods that incorporate engaging activities and connect learning with everyday experiences, as demonstrated in studies on context-based learning (Khasmawati et al., 2022; Lantakay et al., 2023). When students are not provided with meaningful and engaging ways to learn, they are more likely to perceive science as intimidating and difficult to comprehend (Supinah & Soebagyo, 2022).

Compared across the three research sites, Kutai Kartanegara Regency had lower self-efficacy (SE) scores than the two larger cities, Samarinda and Balikpapan. Several studies have demonstrated that self-efficacy varies significantly across students' places of residence. Students living in urban areas generally have greater access to educational resources, which can strengthen their self-efficacy compared to those in rural settings (Bakir, 2020). Furthermore, Jakubowska et al. highlighted that variables such as place of residence can differentiate levels of self-efficacy, with urban residents often reporting higher self-efficacy due to broader social support networks and exposure to diverse educational opportunities (Jakubowska et al., 2020). Conversely, students in rural areas may encounter more significant barriers, including limited access to resources and social isolation, which can hinder the development of their self-efficacy (Arslan & İsbulan, 2020).

This study underscores that although no significant overall differences in STEM self-efficacy were observed between male and female elementary school students, subtle gaps remain, particularly in subcomponents such as engineering and mathematical abilities. These challenges are compounded by gender stereotypes and rigid learning environments, which undermine students' motivation and confidence, especially among girls, to engage in STEM fields fully. To address these challenges, future researchers are encouraged to design targeted interventions, such as developing STEM project-based, inquiry-driven, and collaborative learning approaches.

Opportunity for Self-Efficacy & Motivation in Science Learning at the Elementary Level

Overall, both male and female students demonstrated high levels of self-efficacy, particularly in their confidence to understand and apply scientific concepts for problem-solving. A constructivist approach to science learning supports students in building their own knowledge through exploration and hands-on experiences, thereby enabling them to participate more actively in the learning process and to develop the analytical thinking skills necessary for problem-solving (Amelia & Rusman, 2022).

This confidence is also reflected in students' ability to apply, test, and design science projects. Students with strong self-efficacy tend to set higher goals and show greater persistence when facing challenges (Bilgin et al., 2015; Wahyudiati & Qurniati, 2022). This is particularly relevant in the context of project-based learning (PBL), which has been shown to effectively enhance self-efficacy by giving students ownership of their learning processes, thereby fostering a sense of competence in their scientific abilities (Saepuloh & Suryani, 2020; Wahyudiati & Qurniati, 2022).

When students perceive they can succeed in complex projects, they tend to be more motivated to participate in additional STEM activities in the future (Edirmanasinghe, 2020). This suggests that increased

self-efficacy is not only associated with performance in specific projects but can also broaden students' interest and engagement across STEM disciplines.

Interestingly, although male students demonstrated slightly higher motivation, the difference was not statistically significant. Questionnaire results indicated that students of both genders were equally attracted to science subjects because they were perceived as enjoyable, challenging, and involving numerous experiments. This interest and motivation represent valuable assets that can be further optimized through appropriately designed learning experiences, such as project-based instruction within the STEM framework.

Based on open-ended questionnaire responses from teachers, more than 50% reported never having implemented STEM-based instruction (Science, Technology, Engineering, and Mathematics). This finding, however, indicates a significant opportunity to enhance educational quality in the future, particularly by improving students' self-efficacy and motivation at the elementary school level. Implementing a STEM approach not only equips students with integrated knowledge but also facilitates active learning through problem-solving and collaborative projects. Empirical evidence shows that such hands-on experiences can foster students' self-efficacy in facing academic challenges (Awaludin et al., 2024; Broder et al., 2023), as students who achieve small successes in completing STEM tasks tend to feel more confident in tackling future learning challenges (Fei et al., 2024). One effective process for developing solutions to achieve desired outcomes by applying mathematical, technological, engineering, and scientific principles in STEM learning is through the implementation of the Engineering Design Process (EDP) model (Aini et al., 2024).

The Engineering Design Process (EDP) is characterized by a non-linear and iterative approach that requires students to articulate design problems, investigate existing solutions, generate prototypes, and evaluate their effectiveness through feedback (Krajcik & Delen, 2017; Long et al., 2020). This method promotes active engagement, positioning students not merely as recipients of knowledge but as active participants in their learning journey, aligning with the goals of project-based learning (PjBL) within STEM environments (Muliyati et al., 2023; Rugh et al., 2021). Research indicates that PjBL integrated with EDP significantly enhances students' critical thinking skills and fosters a collaborative atmosphere among learners (Winarno et al., 2020).

In instructional activities, more than 50% of teachers have not implemented game-based learning in science education. This represents a significant opportunity for educators to introduce unique and effective pedagogical strategies that enhance student engagement, understanding, and retention of scientific concepts through the integration of games in science learning. Educational games are among the preferred learning tools for children (Er Nas & Yaman, 2023), and they can foster higher-order thinking skills and student engagement, which are crucial for effective science instruction (Botes, 2022). Educators have reported increased student interest and improved learning experiences when using games as teaching aids (McKendree et al., 2019). Furthermore, game-based learning frameworks have been leveraged to develop innovative curricula that align with educational standards while effectively engaging students through interactive gameplay (Mohamed et al., 2022).

In instructional activities, more than 50% of teachers have not implemented game-based learning in science education. This represents a significant opportunity for educators to introduce unique and effective pedagogical strategies that enhance student engagement, understanding, and retention of scientific concepts through the integration of games in science learning. Educational games are among the preferred learning tools for children (Er Nas & Yaman, 2023), and they can foster higher-order thinking skills and student engagement, which are crucial for effective science instruction (Botes, 2022). Educators have reported increased student interest and improved learning experiences when using games as teaching aids (McKendree et al., 2019). Furthermore, game-based learning frameworks have been leveraged to develop innovative curricula that align with educational standards while effectively engaging students through interactive gameplay (Mohamed et al., 2022).

Teachers also agreed that it is important for educators to consider student diversity when designing instruction. Students are more likely to engage with learning when educators facilitate instruction that aligns with their individual learning styles. Interactive teaching stimulates students' cognitive abilities, such as critical and creative thinking, which are highly relevant in science education (Karim et al., 2023). According to

Ph'Ng, a balanced instructional approach incorporating varied learning activities can sustain student interest and accommodate diverse learning styles (Mei Ph'Ng, 2018). In this way, students with visual, auditory, or kinesthetic learning preferences can become more actively engaged, ultimately promoting improved learning outcomes.

Overall, high student self-efficacy provides a strong foundation for developing competencies in STEM fields. Engagement in relevant projects has been shown to effectively enhance intrinsic motivation and confidence, which are important predictors of academic success and future career interests (Luo et al., 2021). Therefore, the implementation of innovative approaches such as STEM, the Engineering Design Process (EDP), and game-based learning, supported by an inclusive and differentiated learning environment, becomes crucial not only for equipping students with knowledge but also for fostering the self-confidence they need to face future challenges.

CONCLUSION

This study identifies a central paradox: elementary school students inherently possess high levels of motivation and self-efficacy toward science learning, yet this potential remains underutilized due to specific challenges. Overall, no significant differences were found in the average self-efficacy and motivation between male and female students. Nevertheless, the findings reveal several notable gaps, including lower self-efficacy among female engineering students, moderate self-efficacy in mathematical components, and disparities in self-efficacy between urban and non-urban students. These challenges are strongly correlated with students' perceptions that science content is often difficult and non-contextual, as well as with teaching strategies that tend to remain traditional. On the other hand, students' high interest in learning experiences that are enjoyable, challenging, and involve experimentation represents a significant yet underexploited opportunity, particularly given that the majority of surveyed teachers have not implemented innovative instructional approaches such as STEM. These findings underscore the urgency of pedagogical transformation in elementary science education, particularly as a direction for future research. Students' potential and interest cannot be fully realized without a supportive and empowering learning environment. Specifically, the implementation of Project-Based Learning (PjBL) integrated with STEM frameworks and the Engineering Design Process (EDP) is highly recommended. Such approaches can bridge existing gaps, enhance self-efficacy, and make science learning more relevant and engaging. Furthermore, integrating game-based learning with differentiated instruction can accommodate diverse learning styles while maintaining high levels of student engagement.

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REFERENCES

- Abdillah, L. I., Nur, S. H., & Arip, A. G. (2023). Model Pembelajaran Teams Games Tournament Berbasis Keterampilan Proses Sains untuk Meningkatkan Kemampuan Berpikir Kreatif dan Motivasi Belajar Siswa. *Jurnal Educatio FKIP UNMA*, 9(2), 1051-1060. <https://doi.org/10.31949/educatio.v9i2.4472>
- Ahmad, A. L., & Mohamed, Z. (2023). The Profile of Students' Mathematical Representation Competence, Self-Confidence, and Habits of Mind Through Problem-Based Learning Models. *Infinity Journal*, 12(2), 323-338. <https://doi.org/10.22460/infinity.v12i2.p323-338>
- Aini, S. N., Munahefi, D. N., Pramasdyahsari, A. S., & Setyowati, R. D. (2024). Engineering Design Process STEM: Projek Miniatur Gazebo Joglo. *PRISMA, Prosiding Seminar Nasional Matematika*, 7, 37-43.

<https://proceeding.unnes.ac.id/prisma>

- Alam, M. S., Sajid, S., Kok, J. K., Rahman, M., & Amin, A. (2021). Factors influencing high school female Students' intentions to pursue science, technology, engineering, and mathematics (STEM) education in Malaysia. *Pertanika Journal of Social Sciences and Humanities*, 29(2), 839–867. <https://doi.org/10.47836/pjssh.29.2.06>
- Alamsyah, A., Rumanta, M., & Widiasih, W. (2021). Pengaruh Model Pembelajaran Project Based Learning dan Keterampilan Kolaborasi terhadap Hasil Belajar IPA Siswa. *Jurnal Elementaria Edukasia*, 4(2). <https://doi.org/10.31949/jee.v4i2.3147>
- Amelia, D., & Rusman, R. (2022). Sintesis Indikator Lingkungan Belajar Konstruktivis sebagai Instrumen Evaluasi Implementasi Kurikulum Ilmu Pengetahuan Alam. *Edukatif: Jurnal Ilmu Pendidikan*, 4(4), 5794–5803. <https://doi.org/10.31004/edukatif.v4i4.3203>
- Amsbary, J., Yang, H.-W., Sam, A., Lim, C.-I., & Vinh, M. (2023). Practitioner and director perceptions, beliefs, and practices related to STEM and inclusion in early childhood. *Early Childhood Education Journal*. <https://doi.org/10.1007/s10643-023-01476-w>
- Arslan, E., & İsbulan, O. (2020). The Effect of Individual and Group Learning on Block-Based Programming Self-Efficacy and Robotic Programming Attitudes of Secondary School Students. *Malaysian Online Journal of Educational Technology*, 9(1), 108–121. <https://doi.org/10.17220/mojet.2021.9.1.249>
- Ashlock, J., Stojnic, M., & Tüfekçi, Z. (2021). Gender Differences in Academic Efficacy across STEM Fields. *Sociological Perspectives*, 65(3), 555–579. <https://doi.org/https://doi.org/10.1177/07311214211028617>
- Awaludin, A., Ruhiat, Y., & Anriani, N. (2024). Improving Learning Outcomes through STEM Learning Model and Self-Efficacy. *Ideguru: Jurnal Karya Ilmiah Guru*, 9(3), 1175–1180. <https://doi.org/10.51169/ideguru.v9i3.1012>
- Bilgin, I., Karakuyu, Y., & Ay, Y. (2015). The effects of project-based learning on undergraduate students' achievement and self-efficacy beliefs towards science teaching. *Eurasia Journal of Mathematics, Science and Technology Education*, 11(3), 469–477. <https://doi.org/10.12973/eurasia.2014.1015a>
- Botes, W. (2022). Pre-Service Teachers' Experiences on the Development of Educational Science Board Games. *European Journal of STEM Education*, 7(1). <https://doi.org/10.20897/ejsteme/11784>
- Brandon, D. (2000). Self-Efficacy: Gender Differences of Prospective Primary Teachers in Botswana. *Research in Education*, 64, 36–43. <https://doi.org/10.7227/RIE.64.4>
- Broder, E. D., Fetrow, K. J., Murphy, S. M., Hoffman, J. L., & Tinghitella, R. M. (2023). STEM Summer Camp for Girls Positively Affects Self-Efficacy. *American Biology Teacher*, 85(8), 432–439. <https://doi.org/10.1525/abt.2023.85.8.432>
- Buaya, P. (2024). Science, Technology, Engineering, and Mathematics (STEM) Career Interest as Influenced by Mental Rotation Skills and Mathematics Self-Efficacy of Students. *International Journal of Research Publications*, 144. <https://doi.org/10.47119/IJRP1001441320246132>
- Chan, R. C. H. (2022). A social cognitive perspective on gender disparities in self-efficacy, interest, and aspirations in science, technology, engineering, and mathematics (STEM): the influence of cultural and gender norms. *International Journal of STEM Education*, 9(1). <https://doi.org/10.1186/s40594-022-00352-0>
- Edirmanasinghe, N. (2020). Using Youth Participatory Action Research to Promote Self-Efficacy in Math and Science. *Professional School Counseling*, 24(1), 2156759X20970500. <https://doi.org/10.1177/2156759X20970500>
- Elizar, E., & Darmawan, I. G. N. (2019). A Multigroup Invariance Analysis and Gender Difference of Students' Self-efficacy and Attitude Concerning Mathematics. *Jurnal Didaktik Matematika*, 5(2), 1–10. <https://doi.org/10.24815/jdm.v5i2.11640>
- Er Nas, S., & Yaman, H. (2023). An Evaluation of the Educational Games Implementation Process from the Teacher Candidates, Students, and Parents' Perspective. *Malaysian Online Journal of Educational Technology*, 11(4), 291–308. <https://doi.org/10.52380/mojet.2023.11.4.497>
- Espinosa, T., Miller, K., Araujo, I., & Mazur, E. (2019). Reducing the gender gap in students' physics self-efficacy in a team- and project-based introductory physics class. *Physical Review Physics Education Research*, 15(1), 10132. <https://doi.org/10.1103/PhysRevPhysEducRes.15.010132>
- Febri Rafli, M., Syahputra, E., & Yusnadi, Y. (2018). Influence of Problem-Based Learning Model and Early Mathematics Ability on Mathematical Communication Skills and Self-Confidence in Junior High School. *American Journal of Educational Research*, 6(11), 1539–1545. <https://doi.org/10.12691/education-6-11-12>

- Fei, B., Huang, G., & Cai, X. (2024). Improving the cross-cultural consciousness and self-efficacy of college students through STEM education / Mejorar la concienciación transcultural y la autoeficacia de los estudiantes universitarios mediante la educación STEM. *Culture and Education*, 36(2), 479–499. <https://doi.org/10.1177/11356405241261299>
- Fetters, M. D., Curry, L. A., & Creswell, J. W. (2013). Achieving integration in mixed-methods designs: principles and practices. *Health Services Research*, 48(6 Pt 2), 2134–2156. <https://doi.org/10.1111/1475-6773.12117>
- Fuller, C., Aauso, G., Vanvitelli, L., Aldieri, I. L., Sun, L., Yu, Z., & Wang, L. (2023). Gender-moderated effects of academic self-concept on achievement, motivation, performance, and self-efficacy: A systematic review. *Front. Psychol* Gender-moderated effects of academic self-concept on achievement, motivation, performance, and self-efficacy: A sys. https://osf.io/uxjnv/?view_only=bbdbbbddddd
- Gok, T. (2021). The development of the STEM (Science, Technology, Engineering, and Mathematics) attitude and motivation survey towards secondary school students. *International Journal of Cognitive Research in Science, Engineering and Education*, 9(1), 105–119. <https://doi.org/10.23947/2334-8496-2021-9-1-105-119>
- Gumala, Y., Indriyani, T., & Ruby, A. C. (2023). Hubungan Motivasi Belajar dengan Hasil Belajar Siswa Sekolah Dasar. *Journal Basicedu*, 7(6), 3905–3912. <https://doi.org/10.31004/basicedu.v7i6.5786>
- Gusteti, M. U., Rahmalina, W., Azmi, K., Mulyati, A., Wulandari, S., Hayati, R., & Fajriah, N. A. (2024). Mengungkap Potensi Self-Efficacy Melalui Analisis Literatur Dalam Pembelajaran Matematika. *Dharmas Education Journal (DE_Journal)*, 5(1), 168–179. <https://doi.org/10.56667/dejournal.v5i1.1214>
- Hermiati, D., Pranata, O. D., & Lardiman, H. (2024). Motivasi Belajar Siswa Pada Pembelajaran Sains: Studi Komparasi Pada Tiga Sekolah. *PENDIPA Journal of Science Education*, 8(1), 17–26. <https://doi.org/10.33369/pendipa.8.1.17-26>
- Hu, X., Jiang, Y., & Bi, H. (2022). Measuring science self-efficacy with a focus on the perceived competence dimension: using mixed methods to develop an instrument and explore changes through cross-sectional and longitudinal analyses in high school. *International Journal of STEM Education*, 9(1). <https://doi.org/10.1186/s40594-022-00363-x>
- Jakubowska, K., Wysokiński, M., & Chruściel, P. (2020). Place of residence and marital status as variables differentiating a sense of self-efficacy in the elderly—a descriptive cross-sectional survey. *Healthcare (Switzerland)*, 8(3). <https://doi.org/10.3390/healthcare8030300>
- Karim, M., Talukder, M., Mondol, R., Ghose, R., & Hossain, M. (2023). Learning Styles of Undergraduate Medical Students and Their Relation with Preferred Teaching-Learning Methods. *TAJ: Journal of Teachers Association*, 35, 19–26. <https://doi.org/10.3329/taj.v35i2.63690>
- Khasmawati, H., Waluya, S. B., & Asikin, M. (2022). Self-Confidence Siswa Dalam Memecahkan Soal Serupa PISA Berkonten Changes and Relationships. *Jurnal Magister Pendidikan Matematika (JUMADIKA)*, 4(1), 1–7. <https://doi.org/10.30598/jumadikavol4iss1year2022page1-7>
- Krajcik, J., & Delen, İ. (2017). Engaging learners in STEM education. *Eesti Haridusteaduste Ajakiri. Estonian Journal of Education*, 5(1), 35–58. <https://doi.org/10.12697/eha.2017.5.1.02b>
- Lantakay, C. N., Senid, P. P., Blegur, I. K. S., & Samo, D. D. (2023). Hypothetical Learning Trajectory: Bagaimana Perannya dalam Pembelajaran Matematika di Sekolah Dasar? *Griya Journal of Mathematics Education and Application*, 3(2), 384–393. <https://doi.org/10.29303/griya.v3i2.329>
- Levinta, A., Gunowibowo, P., & Sutiarso, S. (2024). Pengaruh Self-efficacy Terhadap Kemampuan Berpikir Kreatif Matematis Siswa dalam Pembelajaran Saintifik. *Indiktika: Jurnal Inovasi Pendidikan Matematika*, 6(2), 232–244. <https://doi.org/10.31851/indiktika.v6i2.15114>
- Long, N. T., Yen, N. T. H., & Van Hanh, N. (2020). The role of experiential learning and the engineering design process in K-12 STEM education. *International Journal of Education and Practice*, 8(4), 720–732. <https://doi.org/10.18488/journal.61.2020.84.720.732>
- López, L. S., & Cabello, V. M. (2022). Starting at Home: What Does the Literature Indicate about Parental Involvement in Early Childhood STEM Education? *Education Sciences*, 12(3). <https://doi.org/10.3390/educsci12030218>
- Luo, T., So, W. W. M., Wan, Z. H., & Li, W. C. (2021). STEM stereotypes predict students' STEM career interest via self-efficacy and outcome expectations. *International Journal of STEM Education*, 8(1). <https://doi.org/10.1186/s40594-021-00295-y>
- Lusidawaty, V., Fitria, Y., Miaz, Y., & Zikri, A. (2020). Jurnal Basicedu. *Jurnal Basicedu*, 4(1), 168–174.

<https://journal.uui.ac.id/ajie/article/view/971>

- Luzin, A., Rozhnov, A. A., Tkachenko, T. V., Shoustikova, T., Tukhvatullina, L. R., & Batrakova, I. A. (2024). Exploring the relationship between self-efficacy beliefs when teaching science and engineering. *Eurasia Journal of Mathematics, Science and Technology Education*, 20(8). <https://doi.org/10.29333/ejmste/14919>
- Mackiewicz, J. (2018). Writing center talk over time: A mixed-method study. In *Writing Center Talk over Time: A Mixed-Method Study*. <https://doi.org/10.4324/9780429469237>
- Magnate, F. R., & Sulatra, J. R. S. (2023). Mathematics Performance as Influenced by Mathematics Anxiety and Self-Efficacy: A Modeling Study. *Journal for Educators, Teachers and Trainers*, 14(5), 290–298. <https://doi.org/10.47750/jett.2023.14.05.028>
- Masitoh, L. F., & Fitriyani, H. (2018). Improving students' mathematics self-efficacy through problem-based learning. *Malikussaleh Journal of Mathematics Learning (MJML)*, 1(1), 26–30. <https://ojs.unimal.ac.id/index.php/mjml/article/view/679/469>
- McKendree, B., McKim, A., & Goodwin, C. (2019). Games in Natural Sciences Education: Exploring the Perspectives of Secondary School Educators. *Natural Sciences Education*, 48. <https://doi.org/10.4195/nse2019.03.0005>
- Mei Ph'Ng, L. (2018). Teaching Styles, Learning Styles, and the ESP Classroom. *MATEC Web of Conferences*, 150, 1–7. <https://doi.org/10.1051/mateconf/201815005082>
- mohamed, heba, Cabalsa, M., Samuel, V., Llaguno, M. B., & Mary Beth, M. R. (2022). Digital Gamification: An Innovative Pedagogy for Anatomy and Physiology Course Among Digital Natives- Nursing Students. *Assiut Scientific Nursing Journal*, 10(28), 10–20. <https://doi.org/10.21608/asnj.2022.110919.1282>
- Muliyati, D., Prastiawan, F., & Mutoharoh, M. (2023). Development of a STEM project-based learning student worksheet for Physics learning on the renewable energy topic. *Journal of Physics: Conference Series*, 2596(1). <https://doi.org/10.1088/1742-6596/2596/1/012078>
- Namaziandost, E., & Çakmak, F. (2020). An account of EFL learners' self-efficacy and gender in the Flipped Classroom Model. *Education and Information Technologies*, 25(5), 4041–4055. <https://doi.org/10.1007/s10639-020-10167-7>
- Negara R P, H., . W., Nurlaelah, E., . M., Heniati Santosa, F., & Bahri, S. (2024). Mathematical Reasoning Ability and Mathematics Self-efficacy in Gender Differences. *KnE Social Sciences*, 2024, 605–612. <https://doi.org/10.18502/kss.v9i13.15964>
- Oje, O., Adesope, O., & Oje, A. V. (2021). Work in Progress: The Effects of Hands-on Learning on STEM Students' Motivation and Self-efficacy: A Meta-Analysis. *ASEE Annual Conference and Exposition, Conference Proceedings, August 2023*. <https://doi.org/10.18260/1-2--38204>
- Putri, D. H., & Pranata, O. D. (2023). Eksplorasi Kejenuhan Siswa dalam Pembelajaran Sains Setelah Pandemi. *Jurnal Inovasi Pendidikan Sains (JIPS)*, 4(2), 62–70. <https://doi.org/10.37729/jips.v4i2.3367>
- Rahmadani, A., Jumadi, J., Wilujeng, I., Suyanta, S., & Afikah, A. (2023). Students' Self-Efficacy in Science Learning Based on Gender. *Jurnal Penelitian Pendidikan IPA*, 9(6), 4143–4150. <https://doi.org/10.29303/jppipa.v9i6.2873>
- Rivera, H., & Li, J. T. (2020). Potential Factors to Enhance Students' STEM College Learning and Career Orientation. *Frontiers in Education*, 5(April). <https://doi.org/10.3389/feduc.2020.00025>
- Rugh, M., Beyette, D., Capraro, M., & Capraro, R. (2021). Using DIME maps and STEM project-based learning to teach physics. *Interactive Technology and Smart Education, ahead-of-print*. <https://doi.org/10.1108/ITSE-07-2020-0109>
- Rusmiati, M. (2022). Realistic Mathematics Education (RME) pada Efikasi Diri Siswa. *Journal Evaluation in Education (JEE)*, 3(3), 97–101. <https://doi.org/10.37251/jee.v3i3.265>
- Saepuloh, D., & Suryani, S. (2020). Application of the project-based learning model to improve students' creative thinking skills and self-efficacy. *Economica*, 9(1), 45–52. <https://doi.org/https://doi.org/10.22202/economica.2020.v9.i1.4250>
- Salam, W. A., Mujib, A., & Noviyanti, M. (2023). Hubungan self-efficacy, gender dan KAM terhadap kemampuan literasi matematis siswa SMP. *Pythagoras: Jurnal Program Studi Pendidikan Matematika*, 12(2), 106–115. <https://doi.org/10.33373/pythagoras.v12i2.5513>
- Samsudin, M. A., Jamali, S. M., Zain, A. N. M., & Ebrahim, N. A. (2020). The effect of STEM project-based learning on self-efficacy among high-school physics students. *Journal of Turkish Science Education*, 17(1), 94–108. <https://doi.org/10.36681/tused.2020.15>

- Sheng, J., Tian, P., Sun, D., & Fan, Y. (2023). Influence of Stem Value Perception on Stem Career Preferences Among Agricultural and Forestry Undergraduates. *Journal of Baltic Science Education*, 22(5), 914–928. <https://doi.org/10.33225/jbse/23.22.914>
- Supinah, R., & Soebagyo, J. (2022). Analisis Bibliometrik Terhadap Tren Penggunaan ICT Pada Pembelajaran Matematika. *JNPM (Jurnal Nasional Pendidikan Matematika)*, 6(2), 276. <https://doi.org/10.33603/jnpm.v6i2.6153>
- Syafi'ah, R., Laili, A. M., & Prisningtyas, N. V. (2022). Analisis Komponen Keterampilan Proses Sains Pada Buku Ajar Ipa Kelas IX. *LENSA (Lentera Sains): Jurnal Pendidikan IPA*, 12(2), 87–96. <https://doi.org/10.24929/lensa.v12i2.230>
- Wahyudiati, D., & Qurniati, D. (2022). Effect of Project-Based Learning on Pre-Service Chemistry Teachers' Self-Efficacy and Critical Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, 8(5), 2307–2311. <https://doi.org/10.29303/jppipa.v8i5.1834>
- Waters, C. C. (2022). Exploring Effective Practices of an Elementary STEM Block Program. *Journal of Research in Science, Mathematics and Technology Education*, 5(3), 195–225. <https://doi.org/10.31756/jrsmte.532>
- Whitcomb, K. M., Kalender, Z. Y., Nokes-Malach, T. J., Schunn, C. D., & Singh, C. (2020). *A mismatch between self-efficacy and performance: Undergraduate women in engineering tend to have lower self-efficacy despite earning higher grades than men.* <http://arxiv.org/abs/2003.06006>
- Winarno, N., Rusdiana, D., Samsudin, A., Susilowati, E., Ahmad, N., & Afifah, R. M. A. (2020). The steps of the Engineering Design Process (EDP) in science education: A systematic literature review. *Journal for the Education of Gifted Young Scientists*, 8(4), 1345–1360. <https://doi.org/10.17478/jegys.766201>
- Yanti, R. A., Syamsuri, S., Yuhana, Y., & Mutaqin, A. (2024). Meta-Analysis: The Effect of Project-Based Learning on students' mathematical ability in Indonesia. *International Journal of Research Publication and Reviews*, 5(2), 3505–3512. <https://doi.org/10.55248/gengpi.5.0224.0613>
- Yusuf, I., Ma'rufi, & Nurdin. (2022). Pendekatan STEM untuk Meningkatkan Kemampuan Berpikir Kritis dan Motivasi Belajar Siswa pada Pembelajaran Matematika. *Kognitif: Jurnal Riset HOTS Pendidikan Matematika*, 2(1), 26–40. <https://doi.org/10.51574/kognitif.v2i1.404>