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Factors influencing teaching and learning in upper secondary STEM education in Thailand: Case studies of Nakhon Sawan and Uthai Thani Provinces, Thailand

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ABSTRACT

This study aimed to explore the relationships between factors that affect learning and teaching in STEM education among Thai senior high school students. The study focused on four main factors: teacher learning design factor, student factor, teacher factor, and learning materials factor. A quantitative research design was used. Data were collected from 867 students in grade 10 to grade 12 from schools in Nakhon Sawan, Uthai Thani, and Chai Nat provinces during the 2024 academic year. The research instrument was a questionnaire with 57 items on a 5-point Likert scale. Statistical analyses included the Kolmogorov-Smirnov test, Shapiro-Wilk test, Kruskal-Wallis H test, pairwise comparisons analysis, and one-way ANOVA. The findings showed that the student factor, teacher factor, and learning materials factor had significant positive relationships with students' perceptions of STEM education. Students who were more engaged, had effective teachers, and had access to good learning materials had more positive views of STEM learning. However, the teacher learning design factor did not have a significant impact, which may reflect Thailand's traditional lecture-based teaching style. The study also found gender differences, especially in the perceptions of LGBTQ+ students compared to male and female students. These results suggest the need for student-centered teaching methods and better learning resources to improve student engagement in STEM education.

Keywords: STEM education, Thai senior high school students, learning and teaching factors, perception of education

INTRODUCTION

STEM education, encompassing the fields of science, technology, engineering, and mathematics, is increasingly recognized as a critical component in education systems worldwide, with the aim of equipping students with essential skills for the 21st century. The integration of STEM subjects into education is intended to foster creativity, analytical thinking, and problem-solving abilities, which are fundamental for both personal development and broader economic advancement (Bybee, 2010). As technological advancements continue to reshape industries and economies, education systems around the globe are under pressure to produce graduates equipped to thrive in STEM-related fields. Many countries, including Thailand, have acknowledged the importance of strengthening STEM education to bridge the workforce gap in these high-demand areas (Office of the Basic Education Commission [OBEC], 2021). Strengthening STEM education is increasingly recognized as essential for addressing workforce shortages in high-demand industries, especially in Thailand. Integrating STEM into educational policies aims to enhance human capital, foster economic growth, and drive innovation. This response will explore the importance of STEM education in Thailand, the challenges it faces, and the initiatives underway to bridge the workforce gap (Assouline et al., 2023; Baydakov, 2023; Dahsah, 2022; Karpudewan, 2022; Yamada, 2023).

In Thailand, STEM education has become a central component of educational reform, aligning with the government's vision for an innovation- and technology-driven economy. Policies such as Thailand 4.0 emphasize the need for a knowledge-based economy, with a strong focus on developing human capital in STEM fields (National Economic and Social Development Council [NESDC], 2017). This has led Thai policymakers and educators to prioritize not only the integration of STEM curricula but also the effectiveness of these programs in boosting students' understanding, skills, and interest in STEM. A key factor in the success of these initiatives is students' perception of STEM education, as these perceptions significantly influence engagement, motivation, and academic outcomes (Jolly, 2014). But Thailand continues to face challenges in improving PISA scores compared to neighboring countries such as Vietnam, Hong Kong, the Philippines, and Indonesia. Hong Kong consistently ranks among the highest globally, demonstrating a strong education system that emphasizes academic skills (OECD, 2019). Vietnam, despite being a developing country, has outperformed many in the region due to its focus on quality basic education (World Bank, 2018). In contrast, Thailand's PISA scores remain lower, facing issues such as resource allocation and educational equity, which impact student learning outcomes (Educational Testing Center, 2020). The Philippines and Indonesia also struggle with lower PISA scores, encountering challenges like access to resources and educational inequality. Both countries are beginning to implement policies aimed at enhancing educational quality (World Bank, 2020). for Thailand, advancing STEM education and addressing these foundational challenges are crucial to closing the gap with top-performing countries in the region.

The perception of STEM education learning and teaching are shaped by multiple factors, including teacher effectiveness, the quality of learning materials, and individual attitudes toward learning. For example, teachers play a significant role in shaping students' perceptions by delivering STEM content in an engaging and accessible manner (Foster, 2013). Teaching approaches that include hands-on activities and real-world applications have been shown to positively impact students' interest and understanding of STEM subjects (Beers, 2011). Additionally, the availability and quality of STEM learning materials, such as laboratory equipment and digital resources, are also essential in fostering an environment conducive to learning (Bybee, 2013). Research shows that high-quality learning materials can enhance students' engagement and contribute to more positive perceptions of STEM subjects (Dugger, 2010).

Furthermore, students' attitudes toward STEM education are influenced by personal factors, including prior experiences, self-efficacy, and family support (Schunk & Pajares, 2002). Positive attitudes towards STEM subjects can increase students' motivation and interest, leading them to pursue further studies and careers in these fields. In contrast, students with low self-efficacy in STEM may perceive these subjects as challenging, which can lead to disengagement (Bandura, 1997).

This study aims to examine the relationship between these influential factors such as teacher learning design factors, students factors, teachers factors, and learning materials factors (Samngamjan et al., 2024) and perception of STEM education learning and teaching in high school level in Thailand. By investigating these relationships, this study seeks to provide insights for educators and policymakers on how to effectively improve STEM teaching and learning. Ultimately, the findings will contribute to the development of targeted strategies that align with students' needs, enhance their perceptions of STEM education, and encourage a more positive outlook towards careers in STEM fields.

LITERATURE REVIEW

The Importance of STEM Education

STEM education, which includes science, technology, engineering, and mathematics, is very important for preparing students with the skills they need in the 21st century, such as problem-solving, creativity, and critical thinking (Bybee, 2010). Many countries around the world are focusing on improving STEM education to help grow their economies and develop a stronger workforce (OBEC, 2021). In Thailand, the government introduced the Thailand 4.0 policy to encourage learning in science and technology to support the country's future needs (NESDC, 2017).

Challenges in STEM Education in Thailand

Even though STEM education is a priority, Thailand still faces many challenges. The country's students often score lower in international tests like PISA compared to nearby countries such as Vietnam and Hong Kong (OECD, 2019). Many factors affect how students see STEM education, including how good their teachers are, the quality of their learning materials, and their personal interest and confidence (Dugger, 2010; Foster, 2013; Schunk & Pajares, 2002). Studies show that when students have good teachers and useful learning materials, they are more likely to enjoy and be interested in STEM subjects (Beers, 2011; Bybee, 2013).

The Role of Digital Resources and Student Engagement

Recent research has found that digital learning materials and active student participation are very important for successful STEM learning. Martin et al. (2022) showed that students feel more motivated when they can use modern and interactive digital resources in the classroom. This shows that schools should provide updated digital tools to make learning more interesting and meaningful for students.

Gender Diversity and Inclusion in STEM

There is now more attention to making STEM education fair and welcoming for everyone. UNESCO (2023) emphasized that schools should create friendly learning environments that support underrepresented groups, including girls and LGBTQ+ students. When all students feel safe and included, they are more likely to enjoy STEM learning and continue in these fields. This is especially important in this study, which looks at the experiences of different gender groups, including LGBTQ+ students.

Student-Centered Learning Approaches

Traditional teaching methods, where the teacher mostly lectures, may not help students feel engaged in STEM lessons. Lee and Blanchard (2023) found that student-centered learning, which focuses on activities where students can explore and solve problems, works better than lecture-based teaching, especially in diverse classrooms. In Thailand, moving toward more interactive and student-centered teaching is necessary to improve STEM learning experiences.

Table 1. Students by type of gender/grade (N = 867)

Variables	Categories	n	Percentage (%)
Gender	Male	308	35.2
	Female	508	58.0
	LGBTQ+	60	6.8
Grade	Grade 10	296	33.8
	Grade 11	484	55.3
	Grade 12	96	11.0

STEM Education in Southeast Asia

Nguyen et al. (2022) studied STEM education in Southeast Asia and found that schools in the region have both good opportunities and serious challenges. Their research suggested that schools should update their STEM programs to keep up with the fast-changing digital world and make sure that all students have equal access to good learning resources.

Summary of the Literature

In summary, many studies agree that improving STEM education depends on using interesting teaching methods, providing modern learning tools, and creating safe, inclusive classrooms where all students feel welcome. This study adds to previous research by offering new information from Thailand, especially by looking at the views of different gender groups and their experiences in STEM learning.

Research Objectives

To study the relationship between the perception in STEM education of Thai senior high school students.

METHODOLOGY

Sample Group

The sample used for the study consists of 867 high school students (grade 10-grade 12) in the academic year 2024 from Nakhon Sawan, Uthai Thani, and Chai Nat provinces. The breakdown is as follows: 296 students from grade 10, 484 students from grade 11, and 96 students from grade 12, as shown in **Table 1**.

Data Collection and Analysis

Step 1

Analyzing the questionnaire on factors influencing perceptions of STEM education teaching and learning, based on Samngamjan et al. (2024, p. 54), as preliminary data for this research. The questionnaire consists of four components:

(1) teacher learning design factors (31 items),

(2) student factors (10 items),

(3) teacher factors (10 items), and

(4) learning materials factors (6 items), totaling 57 items.

This analysis aims to explore the relationship between the perception in STEM education of Thai senior high school students.

Using a 5-level rating scale (Likert, 1932) by setting the level of opinion in each score range and meaning as follows:

(1) 1 means if students think that this question never occurs in class / disagree the most,

(2) 2 means if students think that this question almost never occurs in class / disagree,

(3) 3 means if students think that this question sometimes occurs in class / not sure / neutral,

(4) 4 means if students think that this question occurs in class almost all the time / agree the most, and

(5) 5 means if students think that this question occurs in class all the time / agree the most.

Step 2

Step 2 involves conducting statistical analyses, including testing of data distribution, the independent-samples Kruskal-Wallis test, pairwise comparisons analysis, and one-way ANOVA, to examine the relationship between the perception in STEM education of Thai senior high school students.

RESULTS

A study the relationship between the perception in STEM education of Thai senior high school students The research results found that

Table 2. Results of the analysis of tests of normality

Factor	Sex	Kolmogorov-Smirnov			Shapiro-Wilk		
		df	Statistic	Significance	df	Statistic	Significance
Teacher learning design	Male	308	.112	.000	308	.956	.000
	Female	508	.095	.000	508	.958	.000
	LGBTQ+	60	.139	.006	60	.946	.010
Students	Male	308	.087	.000	308	.957	.000
	Female	508	.104	.000	508	.977	.000
	LGBTQ+	60	.250	.000	60	.896	.000
Teachers	Male	308	.107	.000	308	.947	.000
	Female	508	.132	.000	508	.962	.000
	LGBTQ+	60	.232	.000	60	.890	.000
Learning materials	Male	308	.112	.000	308	.972	.000
	Female	508	.137	.000	508	.969	.000
	LGBTQ+	60	.113	.056	60	.961	.050

Note. N = 876; Male = 308; Female = 508; & LGBTQ+ = 60

Table 3. Results of the Kruskal-Wallis test for factors with no significant differences

Factor	Item		
	Test statistic	df	Asymptotic significance (2-sided test)
Teacher learning design	5.623	2	.060
Teachers	5.252	2	.072

Note. N = 876; Male = 308; Female = 508; & LGBTQ+ = 60

Table 4. Results of the Kruskal-Wallis test for factors with significant differences

Factor	Item				
	Test statistic			df	Asymptotic significance (2-sided test)
	LGBTQ+-female	LGBTQ+-male	Female-male		
Students	104.181	164.135	59.954	2	.000
Learning materials	145.743	175.198	29.455	2	.000

Note. N = 876; Male = 308; Female = 508; & LGBTQ+ = 60

Table 5. Results of pairwise comparisons for the students factor across genders

Sample 1-sample 2	Test statistic	Standard error	Standard value	Significance	Adjusted significance
LGBTQ+-female	104.181	34.447	3.024	.002	.007
LGBTQ+-male	164.135	35.609	4.609	.000	.000
Female-male	59.954	18.223	3.290	.001	.003

Note. N = 876; Male = 308; Female = 508; & LGBTQ+ = 60

(1) The results of testing data distribution across each factor group, using Kolmogorov-Smirnov and Shapiro-Wilk tests, assess whether the data follows a normal distribution. This is a crucial step for ensuring the accuracy of data analysis (Ghasemi & Zahediasl, 2012; Razali & Wah, 2011). The results of the analysis are presented as follows:

From **Table 2**, using the Kolmogorov-Smirnov and Shapiro-Wilk tests show statistical significance values ranging from .000 to .050, which are below the .05 level. This indicates that the data does not follow a normal distribution. Therefore, t-tests cannot be used. Since there are more than two groups, non-parametric statistics such as the Kruskal-Wallis H test are required, as it is suitable for data that does not assume a normal distribution when analyzing differences between groups (Ghasemi & Zahediasl, 2012; Razali & Wah, 2011).

(2) The results of this study utilized the Kruskal-Wallis H test to examine whether there are significant differences in students' perceptions of STEM education teaching among different gender groups. The results of the test are presented in **Table 2** and **Table 3**.

Table 3 shows that gender does not significantly influence students' perceptions of STEM education teaching in certain areas. Specifically, there is no significant gender difference in perceptions of teacher learning design (value = 5.623, df = 2, p = 0.060) or teachers (value = 5.252, df = 2, p = 0.072). Since both p-values are greater than 0.05, this indicates that the differences between gender groups are not statistically significant. Therefore, it can be concluded that gender does not impact students' perceptions in the areas of teacher learning design and teachers.

Table 4 indicates that gender significantly influences students' perceptions of STEM education teaching in specific areas, notably in students and learning materials, both with p-values of .000. This demonstrates significant differences between gender groups. Thus, it can be concluded that gender impacts students' perceptions in the areas of students and learning materials.

(3) The results of the pairwise comparisons analysis to identify which pairs of gender groups have statistically significant differences in students' perceptions of STEM education among secondary school students in Thailand. The results are as follows:

From **Table 5**, significant statistical differences were found between different gender groups as follows:

Table 6. Results of pairwise comparisons for the learning materials factor across gender

Sample 1-sample 2	Test statistic	Standard error	Standard value	Significance	Adjusted significance
LGBTQ+-female	145.743	34.297	4.249	.000	.000
LGBTQ+-male	175.198	35.453	4.942	.000	.000
Female-male	29.455	18.144	1.623	.104	.313

Note. N = 876; Male = 308; Female = 508; & LGBTQ+ = 60

Table 7. One-way ANOVA

Factor	N	Mean	Standard deviation	ANOVA		
				Sex	Province	Class
Teacher learning design	876	3.708	.680	.260	.000	.000
Students	876	3.227	.890	.000	.051	.000
Teachers	876	3.661	.740	.340	.028	.000
Learning materials	876	3.279	.903	.000	.001	.000

1. LGBTQ+ vs. female: A significant difference was observed (value = 104.181, adjusted significance = 0.007). This indicates that there is a significant difference in perceptions of STEM education teaching between the LGBTQ+ group and the female group.
2. LGBTQ+ vs. male: A significant difference was observed (value = 164.135, adjusted significance = 0.000). This indicates that there is a significant difference in perceptions of STEM education teaching between the LGBTQ+ group and the male group.
3. Female vs. male: A significant difference was observed (value = 59.954, adjusted significance = 0.003). This indicates that there is a significant difference in perceptions of STEM education teaching between the female group and the male group.

From **Table 6**, the analysis results between different gender groups are as follows:

1. LGBTQ+ vs. female: A significant difference was observed (value = 145.743, adjusted significance = 0.000). This indicates that there is a significant difference in perceptions of STEM education teaching between the LGBTQ+ group and the female group.
2. LGBTQ+ vs. male: A significant difference was observed (value = 175.198, adjusted significance = 0.000). This indicates that there is a significant difference in perceptions of STEM education teaching between the LGBTQ+ group and the male group.
3. Female vs. male: No significant difference was observed (value = 29.455, adjusted significance = 0.313). This indicates that there is no significant difference in perceptions of STEM education teaching between the female group and the male group.

(4) The results of the one-way ANOVA

From **Table 7** presents the results of a one-way ANOVA. The findings indicate that students across different grade levels have statistically significant differences in their perceptions of STEM education at the 0.05 level. In contrast, gender and province do not exhibit statistically significant differences in students' perceptions of STEM education.

DISCUSSION

The research findings reveal that the teacher learning design factor, student factor, teacher factor, and learning materials factor are significantly related to students' perceptions of STEM education in Thailand. These factors demonstrate that students' perceptions of STEM learning are influenced by multiple elements within the current educational context.

The study found that student and teacher factors significantly affect students' perceptions of STEM education. This aligns with research by Schunk and Pajares (2002), which highlights that students' attitudes and teachers' effectiveness directly impact students' self-confidence and motivation to learn STEM (Schunk & Pajares, 2002). Teaching methods that engage students such as hands-on activities and problem-based learning are shown to positively impact students' understanding and attitudes towards STEM (Beers, 2011). Additionally, the support teachers provide is critical in fostering motivation and positive perceptions of STEM (Foster, 2013).

The research also shows that learning materials play an important role in students' perceptions of STEM education. Students who have access to high-quality and engaging resources, such as digital tools or lab equipment, often have a more positive view of STEM learning. This aligns with Dugger's (2010) findings that appropriate learning materials enhance student engagement and problem-solving skills. Modern and relevant learning resources also help students recognize the real-world importance of STEM, leading to more critical thinking.

Interestingly, the study found no significant statistical difference for the teacher learning design factor in students' perceptions of STEM within the Thai context. This may reflect differences in Thailand's educational culture (OECD, 2018). Teachers in Thailand may predominantly use lecture-based or traditional methods, which may not effectively engage students in STEM (Bybee, 2013). Bybee's (2013) research suggests that flexible, problem-based learning approaches in STEM teaching yield positive results on student perceptions. However, implementing such curricula in Thailand may face challenges in terms of resources and structural limitations.

This research highlights the importance of resource support and teacher skill development in STEM education to meet students' needs. Teaching strategies that emphasize student engagement, diverse learning materials, and real-world applications can foster more meaningful and lasting learning. Additionally, training programs that encourage collaborative and hands-on learning approaches could help bridge learning gaps between Thailand and other countries with stronger STEM education development (OECD, 2018).

CONCLUSIONS

This study finds significant relationships between students' perceptions and the student, teacher, and learning materials factors, suggesting that students' understanding and attitudes toward STEM education are shaped by both individual and external influences.

The significant impact of the student and teacher factors highlights the crucial roles of student engagement and teacher effectiveness in STEM learning. Teachers who adopt engaging, interactive teaching methods and who build supportive learning environments play a key role in enhancing students' perceptions of STEM (Schunk & Pajares, 2002). Furthermore, access to high-quality practical learning materials positively influences students' views, underlining the importance of resource availability in STEM education (Dugger, 2010).

Interestingly, the teacher learning design factor did not yield statistically significant differences, possibly reflecting Thailand's reliance on traditional, lecture-based teaching methods, which may not align with the engagement-driven needs of STEM education (Bybee, 2013; OECD, 2018). This suggests that adopting more interactive, problem-based learning approaches might better support students' understanding of STEM.

In conclusion, this study underscores the importance of addressing diverse factors to improve STEM education perceptions among Thai students. To enhance students' interest and achievement in STEM fields, educational stakeholders may consider increasing support for teacher training in innovative teaching methods, ensuring the provision of quality learning materials, and promoting a classroom culture that encourages exploration and critical thinking. Future studies could further explore the role of specific cultural and institutional factors in shaping effective STEM education practices, offering insights into more tailored, context-appropriate strategies (Beers, 2011).

Contribution to the Literature

This study makes a valuable contribution to the field of STEM education by providing new evidence from Thai senior high school students. It highlights the importance of student engagement, teacher support, and access to quality learning materials in shaping students' positive perceptions of STEM learning. One of the unique contributions of this study is the inclusion of gender diversity, especially the experiences of LGBTQ+ students, which are often overlooked in STEM research. The study also shows that traditional teacher learning design methods may not be effective in the Thai context, suggesting that teaching styles in Thailand need to become more interactive and student-centered. These findings can help educators and policymakers improve STEM teaching in Thailand and in other countries with similar educational systems. By focusing on creating more inclusive and engaging STEM learning environments, this study supports the development of teaching practices that can better motivate students to pursue STEM in the future.

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