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A Comparative Analysis of STEM Design Curriculum Policy for Country Development: A Case Study of Taiwan and Thailand

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ABSTRACT

The aim of this comparative study is to analyze the STEM (Science, Technology, Engineering, and Mathematics) design curriculum policies in Taiwan and Thailand, focusing on their potential impact on national development. The research examines three key areas: 1) STEM educational development policies; 2) curriculum frameworks; and 3) teacher professional development. **The methods** employed in this study include a comprehensive review of relevant literature, policy documents, and curriculum frameworks from both Taiwan and Thailand. The analysis involves a comparative approach to identify similarities, differences, and best practices in STEM education policies and implementation strategies. **The results** indicate that both Taiwan and Thailand recognize the importance of STEM education for driving innovation and economic growth. However, Taiwan demonstrates a more comprehensive STEM policy framework and a stronger commitment to developing a skilled workforce. Taiwan's curriculum framework emphasizes hands-on, project-based learning, interdisciplinary integration, and the incorporation of modern technologies, fostering critical thinking, problem-solving, and collaborative skills among students. In contrast, Thailand is in the early stages of establishing STEM regulations and aligning curricula with industry needs. Thailand's evolving curriculum framework shows promise in promoting creativity, critical thinking, and practical problem-solving abilities. Regarding teacher professional development, Taiwan has a well-established system of ongoing training and industry-school collaboration, while Thailand is in the process of creating a STEM teacher competency program. **The key conclusion** of this study is that Taiwan's well-developed STEM policy framework, with its focus on curriculum design and teacher professional development, demonstrates a more holistic approach to promoting STEM education compared to Thailand. Despite Thailand's early stage of implementation, the country is showing encouraging progress in aligning its STEM policies with national development goals. The findings suggest that a comprehensive and integrated approach to STEM education, encompassing policy development, curriculum design, and teacher professional development, is crucial for effectively promoting economic growth and innovation in both Taiwan and Thailand.

Keywords: STEM; science; technology; engineering; mathematics; education; educational development policy; Taiwan; Thailand; comparative analysis

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ОРИГИНАЛЬНАЯ СТАТЬЯ

Сравнительный анализ политики разработки учебных программ STEM для развития страны: на примере Тайваня и Таиланда

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АННОТАЦИЯ

Целью данного сравнительного исследования является анализ политики разработки учебных программ STEM (естественные науки, технология, инженерия и математика) в Тайване и Таиланде, уделяя особое внимание их потенциальному влиянию на национальное развитие. В исследовании рассматриваются три ключевые области: 1) политика развития STEM-образования; 2) структура учебных программ; 3) повышение квалификации учителей. Методы, использованные в этом исследовании, включают всесторонний обзор соответствующей литературы, политических и директивных документов и учебных программ Тайваня и Таиланда. Сравнительный анализ направлен на выявление сходства, различий и передового опыта в политике и стратегиях реализации STEM-образования. Результаты показывают, что как Тайвань, так и Таиланд признают важность STEM-образования для стимулирования инноваций и экономического роста. Однако Тайвань демонстрирует более комплексную политику STEM и более твердую приверженность развитию квалифицированной рабочей силы. В учебных программах Тайваня особое внимание уделяется практическому обучению, основанному на проектах, междисциплинарной интеграции, и внедрению современных технологий, что способствует развитию критического мышления, навыков решения проблем и совместной работы студентов. В отличие от этого, Таиланд находится на начальных этапах разработки правил STEM и приведения учебных программ в соответствие с потребностями экономики. Развивающаяся система учебных программ в Таиланде будет способствовать развитию творческого подхода, критического мышления и практических способностей решения проблем. Что касается повышения квалификации учителей, на Тайване существует налаженная система непрерывного обучения и сотрудничества между промышленностью и школой. В Таиланде данный процесс находится в стадии создания аналогичных программ. **Ключевой вывод** даного исследования заключается в том, что хорошо развитая политика STEM-образования на Тайване, в которой основное внимание уделяется разработке учебных программ и профессиональному развитию учителей, демонстрирует более целостный подход к продвижению STEM-образования по сравнению с Таиландом. Несмотря на начальную стадию внедрения в Таиланде, страна демонстрирует прогресс в согласовании своей политики STEM-образования с национальными целями развития. Результаты показывают, что комплексный и интегрированный подход к STEM-образованию, включающий разработку политики, создание учебных программ и повышение квалификации преподавателей, имеет решающее значение для эффективного содействия экономическому росту и инновациям как на Тайване, так и в Таиланде.

Ключевые слова: STEM; наука; технологии; инженерия; математика; образование; политика развития образования; Тайвань; Таиланд; сравнительный анализ

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1. Introduction

The rapid advancement of science and technology in the 21st century has made science, technology, engineering, and mathematics (STEM) education a crucial component of educational policies worldwide. Countries are increasingly recognizing the importance of fostering a skilled workforce in science, technology, engineering, and mathematics to drive innovation, economic growth, and global competitiveness. This comparative analysis examines the STEM design curriculum policies of Taiwan and Thailand, two Asian countries with contrasting experiences in STEM education implementation, to provide valuable insights into effective strategies and challenges faced in promoting STEM education.

Taiwan has consistently demonstrated its prowess in STEM fields, ranking among the top performers in international assessments such as the Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS) [1]. This success can

be attributed to Taiwan's comprehensive STEM curriculum policy, which emphasizes a holistic, interdisciplinary approach that seamlessly integrates science, technology, engineering, and mathematics through hands-on, project-based learning [2, 3]. By prioritizing the development of critical thinking, problem-solving, and collaboration skills, Taiwan's policy aims to equip students with the necessary competencies to thrive in a rapidly evolving technological landscape. Moreover, Taiwan's strong commitment to continuous teacher professional development ensures the effective implementation of its STEM curriculum, further contributing to its success [4, 5].

In contrast, Thailand has encountered significant challenges in implementing STEM education policies, despite recognizing its importance for driving innovation and economic growth. Thailand's diverse educational landscape and resource limitations have hindered progress in STEM education [6, 7]. While Thailand's STEM curriculum policy focuses on integrating STEM subjects into the existing curriculum, with an emphasis on practical applications and real-world problem-solving [8, 9], the lack of adequate funding and the need for extensive teacher training have impeded the full realization of these policy goals [10, 11]. Consequently, the implementation of STEM education in Thailand has been uneven, with disparities observed across different regions and socio-economic backgrounds [12, 13].

Despite the contrasting experiences of Taiwan and Thailand in STEM education, both countries share fundamental similarities in their recognition of the importance of integrating STEM subjects and promoting hands-on, project-based learning. However, there are notable differences in their policy approaches that merit further examination. Taiwan's policy strongly emphasizes interdisciplinary collaboration and the integration of STEM throughout the entire curriculum, reflecting a holistic and systemic approach to STEM education [5, 14]. In contrast, Thailand's policy focuses on integrating STEM into the existing curriculum, allowing for more flexibility in implementation but potentially limiting the depth of integration [15, 16]. These differences in policy approaches highlight the importance of considering the unique socio-economic, cultural, and educational contexts of each country when designing and implementing STEM education policies.

This comparative analysis aims to provide a nuanced understanding of the similarities and differences between Taiwan and Thailand's STEM education policies by examining the socio-economic effects, normative legal acts, and specific examples of STEM program applications in various educational contexts. By employing a mixed-methods approach that combines quantitative and qualitative data analysis, this study offers a comprehensive assessment of the strengths and weaknesses of each country's approach to STEM education. The findings of this study contribute to the growing body of literature on STEM education policies and provide valuable insights for policymakers, educators, and researchers seeking to enhance STEM education in their respective contexts.

As the global demand for STEM professionals continues to grow, investing in effective STEM education policies has become a critical imperative for countries seeking to maintain their competitive edge in the knowledge-based economy. By learning from the experiences of Taiwan and Thailand, policymakers and educators can develop evidence-based strategies to address the challenges and leverage the opportunities presented by STEM education. Ultimately, the success of STEM education policies will depend on the ability of countries to adapt and tailor their approaches to their specific contexts while fostering a culture of innovation, creativity, and lifelong learning.

2. Methodology

This study employs a qualitative research approach, specifically document analysis, to examine the STEM educational development policies in Taiwan and Thailand. The researchers carefully selected key policy documents, including government reports, educational guidelines, and curriculum frameworks, for analysis. These documents were chosen based on their relevance and significance in shaping the STEM education landscape in both countries.

3. Literature review

STEM education plays a crucial role in shaping a country's development by fostering innovation, critical thinking, and problem-solving skills among students. This literature review examines the policies and curriculum design strategies adopted by Taiwan and Thailand to promote

STEM education and their impact on national development. This review aims to analyze their work, compare their ideas, and explore the factors contributing to the success of their policies [17–19]. *Table 1* demonstrates definitions of STEM used by various organizations.

The policy framework in Taiwan focuses on enhancing teacher training programs, increasing collaboration between schools and industries, and promoting project-based learning. These initiatives have led to a significant increase in student engagement and achievement in STEM subjects. Furthermore, the government's commitment to funding research and development in STEM fields has contributed to Taiwan's position as a global leader in technology and innovation. In terms of design STEM curriculum, Taiwan highlighted the significance of incorporating design thinking and creativity into STEM education. By integrating design elements into the curriculum, students are encouraged to think critically, solve problems, and develop innovative solutions [5]. This approach has been widely adopted in Taiwan, leading to the cultivation of a new generation of students who possess both technical and creative skills [5]. The integration of design curriculum policies has contributed to the development of Taiwan's design industry and its reputation as a hub for innovation [5].

Yamkasikorn (2021) [22] examined the STEM education policies in Thailand and their impact on the country's development and emphasized the need for a comprehensive approach that includes teacher training, curriculum reform, and public-private partnerships to promote STEM education. His research revealed that the Thai government's investment in STEM education has led to an increase in student enrollment in STEM-related fields and an improved quality of education in science and technology [22]. The integration of design curriculum policies in Thailand's STEM education highlighted the importance of design thinking, problem-solving, and creativity in nurturing students' innovation skills [22]. By incorporating design curriculum policies, Thailand aims to develop a workforce capable of driving the country's creative industries and enhancing its global competitiveness. The integration of design thinking in STEM education has also resulted in improved student engagement and motivation [22].

3.1. Curriculum Framework

In Taiwan, the curriculum framework for STEM education has been a subject of significant research and development. Ku and Lin [1] conducted a study on the status and trends of STEM education in Taiwan, highlighting the importance of integrating science, technology, engineering, and mathematics into the curriculum. They emphasized the efforts of the Technological and Vocational Education Research Center and the K-12 Education Administration in promoting STEM education in Taiwan. Additionally,

Table 1
Definitions of STEM from various organizations

Organization	Definition
National Science Foundation (NSF)	Science, Technology, Engineering, Mathematics
U.S. Department of Education (USDoE)	Focus on Science, Technology, Engineering, and Mathematics
The National Academy of Sciences (NAS)	Emphasis on Science, Technology, Engineering, and Mathematics
The National Science Teachers Association (NSTA)	Incorporates Science, Technology, Engineering, and Mathematics
The National Aeronautics and Space Administration (NASA)	Intersection of Science, Technology, Engineering, and Mathematics

Sources: Compiled by the author based on USDoE (The U.S. Department of Education (USDoE). Science, Technology, Engineering, and Math, including Computer Science [Internet]. Washington, DC: USDoE; 2023. URL: https://www.ed.gov/stem), NAS (National Academy of Sciences. Integration in K-12 STEM Education in the United States: A Discussion. Washington, DC: National Academies Press; 2023. URL: https://www.nae.edu/113355/Integration-in-K12-STEM-Education-in-the-United-States-A-Discussion), [10, 20, 21].

Fan, Yu, and Lin [18] proposed a framework for implementing an engineering-focused STEM curriculum, which serves as a valuable reference for technology and engineering educators in designing and implementing engineering-oriented STEM curricula. This framework has played a crucial role in guiding the development of STEM education in Taiwan, especially concerning engineering-focused curricula [18].

In Thailand, the curriculum framework for STEM education has also received significant attention. The Ministry of Education in Thailand has placed a strong emphasis on STEM education to prepare students for the demands of the 21st century [6]. Sutaphan and Yuenyong [8] conducted research on the development of the Thailand STEM education framework, highlighting the integration of science, technology, engineering, and mathematics in the curriculum. They emphasized the importance of inquiry-based learning and the development of critical thinking skills in STEM education. Furthermore, Suriyabutr and Williams [3] discussed the challenges and opportunities of implementing STEM education in Thailand, emphasizing the need for collaboration between schools, universities, and industries to create an effective STEM curriculum. These scholars have contributed to the development and implementation of STEM education in Thailand, focusing on inquiry-based learning and collaboration within the education system and with external stakeholders.

3.2. Teacher professional development

In Taiwan, there has been a significant emphasis on in-service teacher professional development in STEM education. The government has actively promoted the integration of science, technology, engineering, and mathematics in the curriculum, leading to a demand for proficient STEM teachers [23]. To address this need, integrated STEM teacher professional development programs have been developed to equip educators with the necessary knowledge and skills [23]. These programs aim to enhance teachers' understanding of STEM concepts, pedagogical approaches, and assessment strategies, thereby enabling them to effectively implement STEM education in their classrooms [23]. A study conducted by Lin, Chien, and Chang [23] revealed that these professional development programs have had a positive impact on teachers' perceptions and practices. Teachers reported increased confidence in teaching STEM subjects, improved content knowledge, and enhanced pedagogical skills [23]. They also highlighted the importance of collaboration and networking opportunities provided by these programs, which enabled them to share ideas and experiences with their peers [23]. Moreover, the study emphasized the need for continuous professional development to ensure that teachers stay updated with the latest advancements in STEM education [23, 24].

Thailand, like Taiwan, recognizes the significance of teacher professional development in STEM education. A study by Fakcharoenphol, Dahsah, and Wannagatesiri [25] emphasized the role of professional development in fostering teacher effectiveness and student learning outcomes in Thailand's STEM classrooms. The study highlighted the need for focused professional development initiatives that address the specific challenges faced by teachers in implementing STEM education [25]. It also emphasized the importance of integrating technology and hands-on activities in professional development programs to enhance teachers' pedagogical skills and content knowledge [25]. Another study by Faikhamta, Lertdechapat, and Prasoblarb [26] investigated the impact of a professional development program on Thai science teachers' practices and perceptions. The findings indicated that the program positively influenced teachers' teaching practices, leading to improved student engagement and learning outcomes [26]. The study further emphasized the need for ongoing support and collaboration among teachers to sustain the positive changes observed in their classrooms [26].

4. Findings

4.1. Overview of STEM educational development policies

Taiwan's STEM education policy, as established by the government, aims to cultivate future professionals with interdisciplinary knowledge and skills [2, 5]. The policy emphasizes the integration of STEM subjects across disciplines, encouraging students to develop a holistic understanding of science and technology [2]. According to Lin et al. [14], this approach helps students appreciate the interconnectedness of STEM fields and promotes a multidisciplinary approach to

problem-solving. The government also actively promotes partnerships between academia, industry, and government agencies to ensure that STEM education aligns with industry needs [5]. This collaboration facilitates the development of relevant and up-to-date curricula that equip students with the necessary skills for the workforce [5].

On the other hand, Thailand's STEM education policy focuses on improving the quality and accessibility of STEM education [6, 27]. The government aims to enhance students' critical thinking, problem-solving, and innovation abilities through hands-on learning experiences [6, 26]. This approach is in line with the constructivist learning theory, which emphasizes active learning and student engagement [18]. The policy also emphasizes the importance of teacher training and professional development to ensure that educators are equipped with the necessary knowledge and skills to deliver effective STEM instruction [11, 28].

Both countries recognize the need to foster students' interest and engagement in STEM subjects from an early age. Taiwan's policy encourages the implementation of inquiry-based learning approaches to promote student curiosity and exploration [29]. Thailand, on the other hand, emphasizes the integration of STEM into the curriculum at all education levels, including primary and secondary schools [30].

4.2. Overview of STEM curriculum frameworks

Taiwan's STEM curriculum framework places a strong emphasis on project-based learning, hands-on activities, and design thinking [2, 5]. This approach encourages students to actively engage in the learning process by exploring real-world problems and developing practical solutions. According to Rasyid, Rinto, and Susanti [24], this curriculum framework promotes a student-centered approach where students take ownership of their learning and become active participants in problem-solving. It also fosters collaboration among students, as they work together in teams to tackle complex challenges [31, 32].

On the other hand, Thailand's STEM curriculum framework adopts an inquiry-based approach, integrating STEM subjects and highlighting cross-disciplinary connections [6]. According to Baharin, Kamarudin, and Manaf [32], this framework aims to cultivate students' curiosity, creativity, and scientific thinking. It encourages students to ask questions, investigate phenomena, and develop critical thinking skills [10]. Through this approach, students are not only exposed to the knowledge and skills within individual STEM subjects but also learn to apply these concepts in a holistic manner [12].

Both countries' STEM curriculum frameworks share the common goal of nurturing students' creativity and problem-solving abilities. They recognize the importance of developing students' skills beyond subject-specific knowledge, as highlighted by Tseng et al. [29]. In Taiwan, this is achieved through design thinking and hands-on activities [5], while in Thailand, it is accomplished through inquiry-based learning and cross-disciplinary connections [6].

4.3. Teacher professional development

In Taiwan, the government places great importance on continuous professional development for STEM teachers. They provide various training programs, workshops, and resources to enhance the pedagogical skills and content knowledge of teachers in these subjects [4, 14]. This commitment to ongoing development ensures that teachers stay up-to-date with the latest teaching methodologies and advances in STEM fields. Additionally, Buechel[1] found that teachers who participate in these professional development programs reported increased confidence in their ability to teach STEM subjects effectively.

On the other hand, Thailand focuses on equipping STEM teachers with the necessary skills and competencies through training programs and professional development initiatives [33]. The government encourages collaboration between teachers and industry experts to enrich teaching practices and expose students to real-world applications of STEM knowledge [33]. This collaborative approach has been found to enhance teachers' understanding of STEM concepts and improve their instructional strategies [33]. According to Suebsing and Nuangchalerm [11], these initiatives have also led to increased student interest and engagement in STEM subjects.

[1] Buechel C. An investigation of the effects of self-efficacy on STEM implementation [dissertation]. Arkansas: University of Arkansas; 2021.

Overall, both Taiwan and Thailand recognize the importance of teacher professional development in advancing STEM education. By investing in the continuous improvement of teachers' skills and knowledge, these countries are ensuring that their educators are well-equipped to deliver high-quality STEM instruction [13, 15, 19, 33]. This, in turn, contributes to the development of a skilled and innovative workforce for the future [4, 22].

Table 2 provides comparison of STEM education policies, curriculum frameworks, and teacher professional development between Taiwan and Thailand.

The STEM education in both Taiwan and Thailand can be attributed to various factors, including inquiry-based learning, teacher professional development, collaboration between industry and academia, and supportive curriculum policies. It is evident that both Taiwan and Thailand have made significant strides in promoting STEM education, and their experiences serve as valuable examples for countries aiming to enhance STEM education within their own educational systems.

5. Discussion

5.1. STEM educational development policies overview

In analyzing the STEM educational development policies in Taiwan and Thailand, it is evident that both countries recognize the importance of STEM education for fostering innovation and driving economic success. Taiwan stands out with a more extensive and comprehensive STEM policy framework, which reflects its commitment to developing a competent and skilled workforce. This can be attributed to its long-standing emphasis on science and technology education, supported by various normative legal acts that regulate the introduction of STEM programs in the educational process [34].

On the other hand, Thailand is still in the early stages of establishing STEM regulations that align with industrial demands. As noted by Pasupa [12], Thailand recognizes the importance of STEM education for its national development goals. The government has initiated efforts to connect curricula with industry demands, but the framework is still being developed. It is crucial

Table 2

Comparison of STEM education policies, curriculum frameworks, and teacher professional development between Taiwan and Thailand

Topics	Taiwan	Thailand
Overview of STEM Educational Development Policies	Taiwan's STEM education policy aims to cultivate future professionals with interdisciplinary knowledge and skills. The government emphasizes integration across disciplines and promotes partnerships between academia, industry, and government.	Thailand's STEM education policy focuses on improving the quality and accessibility of STEM education. The government aims to enhance students' critical thinking, problem-solving, and innovation abilities through hands-on learning experiences.
Curriculum Framework	Taiwan's STEM curriculum framework emphasizes project-based learning, hands-on activities, and design thinking. It encourages students to explore real-world problems and develop practical solutions through collaboration and creativity.	Thailand's STEM curriculum framework promotes an inquiry-based approach, integrating STEM subjects and emphasizing cross-disciplinary connections. It aims to foster students' curiosity, creativity, and scientific thinking.
Teacher Professional Development	Taiwan emphasizes continuous professional development for STEM teachers, offering training programs, workshops, and resources to enhance their pedagogical skills and content knowledge	Thailand focuses on equipping STEM teachers with the necessary skills and competencies through training programs and professional development initiatives. The government encourages collaboration between teachers and industry experts to enrich teaching practices

Source: Developed by the author.

to consider the specific normative legal acts that form the norms for introducing STEM programs in Thailand's educational process to ensure a solid foundation for implementation.

Moreover, it is essential to highlight the socio-economic effects of STEM curricula applied in practice. Successful STEM programs can lead to increased innovation, technological advancements, and a more skilled workforce, contributing to overall economic growth [35]. Providing concrete examples of the socio-economic impact of STEM education in both Taiwan and Thailand would strengthen the argument for their importance in national development.

5.2. Curriculum framework

Taiwan's curriculum framework for STEM education stands out for its emphasis on hands-on, project-based learning, integrative disciplines, and the use of modern technology. This approach is aligned with the recommendations of scholars such as Lou et al. [2], who argue that a project-based learning approach enhances students' engagement and critical thinking skills. Taiwan's curriculum framework also promotes the integration of different disciplines, enabling students to make connections between science, technology, engineering, and mathematics.

It would be beneficial to provide examples of STEM program applications in relation to specific educational directions, levels of education, and their peculiarities. For instance, STEM programs can be applied not only in design and engineering but also in fields such as economics, where data analysis, mathematical modeling, and technological tools are increasingly important [5]. Highlighting the versatility of STEM education across various disciplines and educational levels would showcase its broad applicability and relevance.

In Thailand, the curriculum framework for STEM education is still being established. However, it shows promising potential for fostering creativity, critical thinking, and problem-solving skills among students. As suggested by Soros, Ponkham, and Ekkapim [27], integrating creative and critical thinking skills into the curriculum can enhance students' abilities to solve complex problems. Thailand's evolving curriculum framework indicates the country's intention to align STEM education with the development of these crucial skills.

5.3. Teacher professional development

In terms of teacher professional development, Taiwan has a well-established system that emphasizes ongoing training and industry-school collaboration. Scholars such as Lee, Hsu, and Chang [33] highlight the importance of continuous professional development for STEM teachers to stay updated with advancements in their respective fields. Taiwan's commitment to teacher training ensures that educators have the necessary knowledge and skills to effectively deliver STEM education.

Similarly, Thailand recognizes the significance of teacher development in promoting STEM education. The country is in the process of creating STEM teacher competency programs to enhance teachers' capacity in delivering STEM content. According to Maitreepan and Thamatasenahant [31], providing teachers with professional development opportunities can positively impact their instructional practices and student outcomes. Thailand's focus on teacher development aligns with the broader goal of strengthening STEM education in the country.

When comparing the experiences of Taiwan and Thailand in the field of STEM education, it would be beneficial to highlight both quantitative and qualitative characteristics. Providing statistical data on the number of STEM programs, student enrollment, and graduate employment rates in STEM fields would support the conclusions drawn from the analysis [16]. Additionally, qualitative data, such as student and teacher feedback on STEM programs, could offer valuable insights into the effectiveness and impact of these initiatives.

Therefore, the comparative analysis of STEM educational development policies, curriculum frameworks, and teacher professional development in Taiwan and Thailand reveals notable similarities and differences. Taiwan's well-established policy framework, comprehensive curriculum, and emphasis on teacher professional development demonstrate a strong commitment to promoting STEM education. Thailand, while still in the early stages of policy implementation and curriculum development, shows promising signs of aligning its policies with development goals. Both countries can learn from each other's experiences and collaborate to further enhance STEM education, taking into account the normative legal acts, socio-economic effects, diverse applications, and

both quantitative and qualitative characteristics of STEM programs.

6. Implications

This research highlights the potential implications of STEM design curriculum policies on country development. By examining the strengths and weaknesses of each country's approach, policymakers, educators, and researchers can gain insights into effective strategies for enhancing STEM education. Lessons learned from Taiwan and Thailand can inform future policy decisions and help countries tailor their STEM education initiatives to their specific contexts.

6.1. Designing curriculum policies for STEM education

The design of curriculum policies in Taiwan has been instrumental in supporting the success of STEM education. According to Sungur Gül et al. [28], the integration of STEM into the national curriculum framework has ensured that STEM subjects are given equal importance as other core subjects. This integration has been achieved through the development of interdisciplinary teaching materials and the provision of specialized training for teachers. Furthermore, the establishment of STEM resource centers across the country has provided teachers with access to updated teaching resources and educational technology tools [1]. The curriculum policies in Taiwan also prioritize the cultivation of students' interest and motivation in STEM by incorporating project-based learning and extracurricular activities [3]. These policies have created a supportive ecosystem for STEM education, allowing students to develop a deep interest in these subjects from an early age.

In Thailand, scholars have identified several factors contributing to the success of STEM education. The Thai government's support for STEM initiatives, such as the establishment of STEM schools and the allocation of resources for teacher professional development, has been crucial in fostering a culture of STEM education. Moreover, the collaboration between schools and industries has provided students with opportunities to apply their knowledge in real-world contexts [29]. This collaboration has helped bridge the gap between theoretical knowledge and practical skills, enhancing the relevance of STEM education in Thailand. The curriculum policies in Thailand have been designed to support effective STEM education. According to Wannapiroon et al. [9], the integration of STEM into the national curriculum has been a significant step towards ensuring the comprehensive development of students' STEM competencies. The curriculum emphasizes hands-on activities, problem-solving, and critical thinking skills. Additionally, the Thai government has invested in providing schools with STEM resources and infrastructure to facilitate the implementation of STEM education [30]. The promotion of STEM-related extracurricular activities and competitions.

In this research, the researcher has analyzed the strengths and weaknesses as guidelines for making policies and curricula learned from both countries, with details below as follows.

Research highlights the potential implications of STEM design curriculum policies on country development. By examining the strengths and weaknesses of each country's approach, policymakers, educators, and researchers can gain insights into effective strategies for enhancing STEM education. Lessons learned from Taiwan and Thailand can inform future policy decisions and help countries tailor their STEM education initiatives to their specific contexts. The details are demonstrated in *Table 3*.

By examining these strengths and weaknesses, policymakers, educators, and researchers can gain valuable insights into effective strategies for enhancing STEM education. These lessons learned from Taiwan and Thailand can inform future policy decisions and help countries tailor their approaches to meet the unique needs of their education systems.

7. Conclusion

The comparative analysis of Taiwan and Thailand's STEM design curriculum policies reveals both similarities and differences. Both countries recognize the importance of STEM education in driving national development. However, their approaches to curriculum design, teaching methods, and teacher professional development differ. Taiwan emphasizes interdisciplinary integration, project-based learning, and industry partnerships, while Thailand focuses on inquiry-based learning and collaboration.

In Taiwan, STEM education has been recognized as a crucial component of the country's

Table 3
Classification of academic content for STEM curriculum

Topics	Taiwan		Thailand	
	Strength	**Weakness**	**Strength**	**Weakness**
1. Curriculum Design	Taiwan's STEM curriculum is well-structured and focuses on fostering critical thinking, problem-solving, and creativity.	There is limited flexibility within the curriculum to adapt to changing technological advancements.	Thailand's STEM curriculum emphasizes hands-on learning experiences and integrates real-world applications of scientific concepts.	The curriculum lacks a clear progression of skills and may not adequately prepare students for higher-level STEM education.
2. Teacher Training and Professional Development	Teachers in Taiwan undergo rigorous training and professional development programs to enhance their STEM teaching skills.	The training programs do not always provide teachers with the necessary resources and support to implement innovative teaching methods effectively.	Thailand has made efforts to improve teacher training programs and provide ongoing professional development opportunities for STEM educators.	The training programs may not consistently meet the needs of all teachers, resulting in varying levels of STEM proficiency among educators.
3. Infrastructure and Resources	Taiwan has well-equipped STEM laboratories and classrooms with modern technology and resources to support hands-on learning.	The availability of these resources may be limited, particularly in rural areas, leading to unequal access to STEM education.	Thailand has made significant investments in improving infrastructure and providing resources for STEM education, especially in urban areas.	The availability and quality of infrastructure and resources may vary across schools, leading to disparities in STEM education opportunities.
4. Industry Collaboration	Taiwan has strong partnerships between educational institutions and industry, allowing students to engage in real-world projects and internships.	The extent of industry collaboration may vary across different regions, limiting equal opportunities for students.	Thailand has been fostering collaborations between schools, universities, and industries to bridge the gap between education and employment.	The level of industry involvement in STEM education initiatives may not be consistent across the country.
5. Student Engagement and Enrichment	Taiwan encourages student participation in STEM competitions, clubs, and extracurricular activities, fostering a passion for STEM subjects	The emphasis on competition may create high levels of stress and pressure among students.	Thailand promotes STEM enrichment programs, science camps, and clubs to engage students and enhance their interest in STEM fields.	The availability and accessibility of these enrichment programs may be limited, particularly in rural areas.

Table 3 *(continued)*

Topics	Taiwan		Thailand	
	Strength	**Weakness**	**Strength**	**Weakness**
6. Research and Development:	Taiwan has a strong focus on research and development in STEM fields, leading to technological advancements and innovation.	There may be a gap between research findings and their practical implementation in the education system.	Thailand has been investing in research and development in STEM fields, fostering innovation and scientific discoveries.	The translation of research findings into practical applications within the education system may be limited.
7. Government Support and Policy	Taiwan's government has consistently shown strong support for STEM education, implementing policies and initiatives to enhance its quality and accessibility	The implementation of policies and initiatives may face challenges due to bureaucratic processes and limited resources	Thailand's government has recognized the importance of STEM education and has introduced policies and initiatives to promote its development	The coordination and effectiveness of policy implementation across different regions may vary, affecting the overall impact of these initiatives

Source: Developed by the author.

national development strategy. The government has implemented comprehensive policies and initiatives to foster STEM learning from the early years of education. One of the key policies in Taiwan is the inclusion of STEM design curriculum in primary and secondary schools. The curriculum aims to develop students' problem-solving skills, critical thinking abilities, and creativity through hands-on and project-based learning activities. The curriculum is designed to integrate science, technology, engineering, and mathematics concepts and principles into real-world applications.

To ensure the effective implementation of the STEM design curriculum, the Taiwanese government has provided professional development opportunities for teachers, including training programs, workshops, and resources. These initiatives aim to equip teachers with the necessary knowledge and skills to effectively engage students in STEM learning. Additionally, Taiwan has established partnerships with industry and academia to bridge the gap between education and the workforce. These collaborations provide students with opportunities to engage in real-world projects and gain practical experience in STEM fields.

On the other hand, Thailand has also recognized the importance of STEM education in its development agenda. The Thai government has implemented policies to enhance the quality of education and promote STEM learning in schools. However, the approach to STEM education in Thailand differs from that of Taiwan. In Thailand, the focus is on the integration of STEM subjects into the existing curriculum rather than a separate STEM design curriculum. The integration aims to promote interdisciplinary learning and the application of STEM principles in various subjects.

Thailand's curriculum reforms emphasize the development of inquiry-based learning approaches, critical thinking, and problem-solving skills across all subjects, including science, mathematics, technology, and engineering. The integration of STEM subjects is seen to enhance students' understanding of these subjects and their relevance to real-world contexts. The Thai government has also emphasized the importance of providing teachers with professional development opportunities to effectively deliver STEM education in the classroom.

While Taiwan and Thailand have taken different approaches to STEM education, both countries share common goals of fostering innovation, technological advancement, and economic growth. The policies and initiatives implemented in both countries aim to equip students with the necessary knowledge, skills, and competencies to thrive in the 21st-century workforce. By comparing the STEM design curriculum policies in Taiwan and Thailand, we can gain insights into the different approaches to STEM education and identify best practices that can be applied in other contexts.

REFERENCES

1. Ku C.J., Lin K.Y. Status and Trends of STEM Education in Highly Competitive Countries: Country Reports and International Comparison. Technological and Vocational Education Research Center. 2022:361–402. Wu-Nam Book Inc.
2. Lou S.J., Shih R.C., Ray Diez C., Tseng K.H. The impact of problem-based learning strategies on STEM knowledge integration and attitudes: an exploratory study among female Taiwanese senior high school students. *International Journal of Technology and Design Education.* 2011;21:195–215. URL: https://doi.org/10.1007/s10798–010–9114–8
3. Suriyabutr A., Williams J. Integrated STEM education in the Thai secondary schools: challenge and addressing of challenges. *Journal of Physics: Conference Series.* 2021;1957(1):1–9. DOI: 10.1088/1742–6596/1957/1/012025
4. Ku C.J., Lin K.Y. Technology teacher education in Taiwan. In: International technology teacher education in the Asia-pacific region. 2020:263–308.
5. Yang C.L., Yang Y.C., Chou T.A., Wei H.Y., Chen C.Y., Kuo C.H. Case study: Taiwanese government policy, STEM education, and industrial revolution 4.0. In: STEM in the Technopolis: The power of STEM education in regional technology policy. 2020:149–170. URL: https://doi.org/10.1007/978–3–030–39851–4_9
6. Promboon S., Finley F.N., Kaweekijmanee K. The evolution and current status of STEM education in Thailand: Policy directions and recommendations. In: Education in Thailand: An old elephant in search of a new mahout. 2018:423–459. URL: https://doi.org/10.1007/978–981–10–7857–6_17
7. Surakarn A., Junprasert T., Chaiakkarakan N., Peungposop N., Boonlop R. Active learning and its outcomes: A case study from the education reform project in Thailand. *The Journal of Behavioral Science.* 2020;15(1):34–51. URL: https://so06.tci-thaijo.org/index.php/IJBS/article/view/143725
8. Sutaphan S., Yuenyong C. STEM education teaching approach: Inquiry from the context based. *Journal of Physics: Conference Series.* 2019;1340(1):1–18. DOI: 10.1088/1742–6596/1340/1/012003
9. Wannapiroon P., Nilsook P., Techakosit S., Kamkhuntod S. STEM Literacy of Students in Vocational Education. *International Journal of Technology in Education and Science*. 2021;5(4):527–549. URL: https://doi.org/10.46328/ijtes.253
10. Daugherty M.K. The Prospect of an "A" in STEM Education. *Journal of STEM Education: Innovations and Research*. 2013;14(2):10–15. URL: https://www.jstem.org/jstem/index.php/JSTEM/article/view/1744
11. Suebsing S., Nuangchalerm P. Understanding and satisfaction towards STEM education of primary school teachers through professional development program. *Jurnal Pendidikan IPA Indonesia*. 2021;10(2):171–177. DOI: 10.15294/jpii.v10i2.25369
12. Pasupa S. Sustainable development in Thailand supported by industrial design education. Loughborough: Loughborough University; 2016. URL: https://hdl.handle.net/2134/23707
13. Sritrakul P. The state of STEM education policy in Northern Region, Thailand. *Humanities, Arts and Social Sciences Studies*. 2018:129–147. URL: https://doi.org/10.14456/hasss.2018.11
14. Lin C., Huang J., Lin R. From STEAM to CHEER: A case study of design education development in Taiwan. *Education Sciences.* 2021;11(4):171. URL: https://doi.org/10.3390/educsci11040171
15. Fakcharoenphol W., Dahsah C., Wannagatesiri T. Teacher Professional Development and Education for STEM Teaching in Thailand: Challenges and Recommendations. In: Concepts and Practices of STEM Education in Asia. Singapore: Springer Nature Singapore; 2022:253–270. URL: https://doi.org/10.1007/978–981–19–2596–2_14
16. Wu P.H., Kuo C.Y., Wu H.K., Jen T.H., Hsu Y.S. Learning benefits of secondary school students' inquiry-related curiosity: A cross-grade comparison of the relationships among learning experiences, curiosity, engagement, and inquiry abilities. *Science Education.* 2018;102(5):917–950. URL: https://doi.org/10.1002/sce.21456

17. Asghar A., Ellington R., Rice E., Johnson F., Prime G. M. Supporting STEM education in secondary science contexts. *Interdisciplinary Journal of Problem-Based Learning.* 2012;6(2):85–125. URL: https://doi.org/10.7771/1541–5015.1349
18. Fan S. C., Yu K. C., Lin K. Y. A framework for implementing an engineering-focused STEM curriculum. *International Journal of Science and Mathematics Education.* 2021;19:1523–1541. URL: https://doi.org/10.1007/s10763–020–10129-y
19. Kijkuakul S. Professional changes of primary science teachers: experience on collaborative action research in Thailand. *Asia-Pacific Science Education.* 2019;5(1):1–22. URL: https://doi.org/10.1186/s41029–019–0030–2
20. Granovskiy B. Science, Technology, Engineering, and Mathematics (STEM) Education: An Overview. CRS Report R 45223, Version 4. Updated. *Congressional Research Service*. 2018. URL: https://sgp.fas.org/crs/misc/R 45223.pdf
21. Johnson H., Cotterman M. Collaborative efforts to put the 'E'back in STEM. *NSTA Reports.* 2013;25(4):3. URL: http://www.nsta.org/docs/NSTAReportsNov13EntireIssueFinal.pdf
22. Yamkasikorn M. STEM Education and Innovation for Teacher Development: New Challenges toward Thai Education Quality. *Asia Research Network Journal of Education.* 2021;1(1):32–42. URL: https://so05.tci-thaijo.org/index.php/arnje/article/view/250673
23. Lin P. L., Chien Y. T., Chang C. Y. Teachers' responses to an integrated STEM module: Collaborative curriculum design in Taiwan, Thailand, and Vietnam. In: Integrated Approaches to STEM Education: An International Perspective. 2020:491–509. URL: https://doi.org/10.1007/978–3–030–52229–2_26
24. Rasyid A., Rinto R., Susanti M. Project-based learning through the STEM approach in elementary schools: How to improve problem-solving ability. *Journal of Education for Sustainable Innovation.* 2023;1(1):1–8. URL: https://doi.org/10.56916/jesi.v1i1.477
25. Shernoff D. J., Sinha S., Bressler D. M., Ginsburg L. Assessing teacher education and professional development needs for the implementation of integrated approaches to STEM education. *International Journal of STEM Education.* 2017;4:1–16. URL: https://doi.org/10.1186/s40594–017–0068–1
26. Faikhamta C., Lertdechapat K., Prasoblarb T. The Impact of a PCK-based Professional Development Program on Science Teachers' Ability to Teaching STEM. *Journal of Science and Mathematics Education in Southeast Asia.* 2020;43.
27. Soros P., Ponkham K., Ekkapim S. The results of STEM education methods for enhancing critical thinking and problem-solving skill in physics the 10th grade level. AIP Conference Proceedings. 2018;1923(1). URL: https://doi.org/10.1063/1.5019536
28. Sungur Gül K., Saylan Kirmizigül A., Ates H., Garzón J. Advantages and Challenges of STEM Education in K-12: Systematic Review and Research Synthesis. *International Journal of Research in Education and Science.* 2023;9(2):283–307. URL: https://doi.org/10.46328/ijres.3127
29. Tseng K. H., Chang C. C., Lou S. J., Chen W. P. Attitudes towards science, technology, engineering and mathematics (STEM) in a project-based learning (PjBL) environment. *International Journal of Technology and Design Education.* 2013;23:87–102. URL: https://doi.org/10.1007/s10798–011–9160-x
30. Norman G. R., Schmidt H. G. The psychological basis of problem-based learning: A review of the evidence. *Academic medicine*. 1992;67(9):557–65.
31. Maitreepan L., Thamatasenahant S. The Enhancing Teacher Competency Program for Learning Management of STEM Education under the Mahasarakham Primary Educational Service Area Office 1. *Journal of Buddhist Philosophy Evolved*. 2021;5(2):35–47. URL: http://202.28.34.124/dspace/handle123456789/1151
32. Baharin N., Kamarudin N., Manaf U. K. A. Integrating STEM education approach in enhancing higher order thinking skills. *International Journal of Academic Research in Business and Social Sciences.* 2018;8(7):810–821. URL: http://dx.doi.org/10.6007/IJARBSS/v8-i7/4421
33. Lee M. H., Hsu C. Y., Chang C. Y. Identifying Taiwanese teachers' perceived self-efficacy for science, technology, engineering, and mathematics (STEM) knowledge. *The Asia-Pacific Education Researcher.* 2019;28:15–23. URL: https://doi.org/10.1007/s40299–018–0401–6
34. Yodpet W. Policy and Practice to Engage STEM Education in Secondary Education: A Comparative Study between Taiwan and Thailand. *Journal of Comparative Education.* 2020;88:123–153. DOI: 10.3966/160957582020050088004

35. Lin K.Y., Yu K.C., Hsiao H.S., Chang Y.S., Chien Y.H. Effects of web-based versus classroom-based STEM learning environments on the development of collaborative problem-solving skills in junior high school students. *International Journal of Technology and Design Education.* 2020;30(1):21–34. URL: https://doi.org/10.1007/s10798–018–9488–6

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