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The Development of STREAM Teaching Unit for Enhancing Students' Creative and Engineering Design Process Skills in the Motion Topic

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This study aimed to develop the STREAM (Science-Technology-Religion-Engineering-Art and Mathematics) teaching model for enhancing grade 8 students' creative and engineering design process skills. The innovative STREAM teaching model consisted six common teaching steps: a) Introduce the STREAM situation; b) Identify the targeted problem; c) Explore and plan to solve the problem; d) Solve the problem and integrate Art; e) Present creatively; and f) Summarize, apply and integrate with moral. Five STREAM lesson plans were designed for teaching the Motion topic. The quality of STREAM lesson plans was established by five experts. After that, the STREAM lesson plans were experimented with 39 Grade 8 students in the first semester of the 2021 academic year at one secondary school located in Songkhla province, Thailand. The research instruments included the Learning Achievement Test and the Engineering Design Process Test. The paired-samples t-test was used to analyze the differences of students' learning achievement and engineering design process skills at the prior and after the STREAM lessons in Motion. The results showed that the STREAM teaching model promoted higher learning achievement and engineering design process skills. The implications of the STREAM for teaching science are finally discussed.

Keywords: STREAM, educational strategies, teaching quality, creative thinking, engineering design process

INTRODUCTION

In recent years, the world has experienced rapid transformation due to the advancements in information, computer, and technology. The key to successfully adapting to these 21st-century changes lies primarily in education. Education serves as the bedrock for the intellectual, emotional, and social development of individuals. It provides them with the essential tools to thrive in their careers, fosters economic competitiveness, and drives innovation. Additionally, education plays a crucial role in meeting human needs and facilitating the development of innovative solutions. In the 21st century, education aims to cultivate vital skills in students, particularly the ability to learn independently and adapt flexibly. The cornerstone of delivering quality education lies in both pre-service and in-service teachers (Koocharoenpisal, 2023).

The importance of creative and engineering design process skills in 21st-century learning is undeniable (Puchongprawet & Chantraukrit, 2022). Effective development of these skills in students hinges significantly on how well teachers manage the learning process. Employing various pedagogical approaches is crucial for nurturing problem-solving abilities. However, it is essential to seamlessly integrate each learning method with others and across different subjects or fields to promote innovation in generating new ideas or products.

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Because of the importance of integrative teaching, the Institute for the Promotion of Teaching Science and Technology (IPST) in Thailand has been at the forefront of advocating for the integration of Science, Technology, Engineering, and Mathematics (STEM) education into the learning and teaching process. IPST places a strong emphasis on science students' practical application of knowledge in their real-life contexts (IPST, 2021). However, in today's competitive careers, STEM alone might not suffice to develop products that can stand out. Therefore, the inclusion of art within STEM education has gradually accepted as a pivotal approach.

Art (A) is integrated into STEM education primarily through product design and creation (Intavimolsri, 2017), evolving into a comprehensive framework for an integrated curriculum (Yakman, 2008). This integration enhances not only the aesthetic appeal of products but also fosters creativity and multidisciplinary thinking among students, thereby contributing to their holistic development in the 21st century. Additionally, Religion (R) is included in STEAM to help students develop their morals and ethics through spiritual and religious teachings.

In this endeavor, we have employed the STREAM education model to craft lesson plans for teaching the topic of Motion to Grade 8 students at Hatyai Ratprachasun School in Songkhla province, located in the southern region of Thailand. These specially designed STREAM education lesson plans are tailored to foster the development of creative and engineering design process skills among Grade 8 students.

LITERATURE REVIEW

This section provides a comprehensive review of the related literature, encompassing learning about the Motion topic in the Basic Education Core Curriculum of Thailand, the utilization of STREAM education for nurturing creative and engineering design process skills, and pertinent research concerning the implementation of STREAM education within the educational landscape of Thailand.

Learning about Motion in the Basic Education Core Curriculum of Thailand

As outlined in the Basic Education Core Curriculum of Thailand B.E. 2551 (A.D. 2008) and its revised edition in B.E. 2560 (A.D. 2017) (Office of the Basic Education Commission (OBEC), Science education encompasses four main areas: Biological Science, Physical Science, Earth and Space Science, and Technology. Within this framework, Motion holds significant importance as a key topic for Grade 8 students, falling under Strand 4: Force and Motion within the science subject. The specific learning outcomes and key performance indicators related to the Motion topic are detailed in Table 1 (Ministry of Education, 2017).

Table 1
Learning about motion in the basic education core curriculum of Thailand

Learning standard	Learning outcomes	Key conceptions
Understanding of the nature of electromagnetic, gravitational and nuclear forces; investigative process of seeking knowledge and applying acquired knowledge for useful and ethical purposes	- Students are able to do experiment and explain finding resultant force of many forces acting on the same object. - Students are able to explain resultant forces acting on static objects or objects moving with constant velocity.	Force is a vector quantity. Net or resultant force is a result of many forces acting on an object. When net force acting on an object is zero, the object will not change their motion. However, when the net force acting on an object is not zero, the object will change its motion.

Utilization of STREAM education for nurturing creative and engineering design process skills

STREAM education is an evolved learning management method derived from STEM Education, integrating religion, arts, and humanities into the traditional STEM framework to foster innovation. This integrated approach aids in the balanced development of both the right and left sides of the brain (Intavimolsri, 2017; Yakman, 2008; Ge, Ifenthaler, & Spector, 2015; Krapaothong, 2018; Saifah, 2014; Riley, 2014). Moreover, STREAM education cultivates critical thinking, encourages investigation, fosters discussion, promotes analysis, and facilitates the integration of knowledge by leveraging the strengths of science, technology, engineering, arts, and mathematics. By blending these diverse fields, this learning management approach addresses the demands of the 21st century and prepares learners for the challenges of the future (Riley, 2014; Siripatrachai, 2013; Triampo & Nokkaew, 2013; Riley, 2016; Khummanee, 2018; Palasonthi, 2016; Hilburn, 2011; Rodkumnerd, 2015).

The learning management approach of STREAM, developed as an extension of STEM education, has been introduced to classrooms by IPST. This integration encompasses the four foundational fields of science, technology, engineering, and mathematics, with the aim of equipping students with the skills necessary for creating innovative products (IPST, 2014), tackling real-world challenges, fostering teamwork, and applying their knowledge in everyday scenarios (Wittawin, Suphawan & Araya, 2017). Through STREAM, learners are empowered to infuse aesthetics into their work (Yakman, 2013), harness their full potential in learning, integrate their knowledge and practical skills, and employ scientific methods to address problems by leveraging the interdisciplinary nature of science, technology, engineering, art, and mathematics (Khummanee, 2018).

The implementation of STREAM education as a learning approach within the educational landscape of Thailand remains relatively rare. However, several research studies have explored the application of STEAM education, which includes the integration of arts (A) alongside science, technology, engineering, and mathematics (STEAM). For instance, Pinitmontree (2018) utilized STEAM education to cultivate 21st-century skills among Grade 7 students through a structured approach involving six teaching steps: Inspiration (I), Learning STEAM education (L), System and Organizing (S), Applying Life and Career Skills (A), Conclusion, and Evaluation (E). Furthermore, Pholmool (2015) implemented STEAM education within the local context of Wangtako Community in Chumphon Province, engaging Grade 9 students. Jampong (2016) applied STEAM education in creative projects focusing on the topic of energy. Additionally, Intavimolsri (2017) employed STEAM education within the biology classroom to foster creativity in science and enhance the learning achievements of Grade 10 students.

Creative and engineering design process skills play a crucial role in data analysis and decision-making, where knowledge and data are leveraged to employ the most optimal methods for problem-solving (Pongwon, 2012). These skills tap into five key aspects of human brain function: memorization, recognition, understanding, diversity, and divergent thinking, which are seamlessly integrated to address various challenges (Guilford, 1967). Problem-solving, therefore, is a systematic cognitive process wherein the most appropriate methods are selected based on knowledge, data, and precision to attain specific goals. The steps involved in harnessing creative and engineering design process skills typically encompass six stages:

a) Introduction to the STREAM situation;

b) Identification of the targeted problem;

c) Exploration and planning to address the problem;

d) Problem-solving and integration of artistic elements;

e) Creative presentation of the solution; and

f) Summarization, application, and integration with ethical considerations.

These steps provide a structured framework for effectively navigating complex challenges while fostering creativity, innovation, and ethical decision-making.

Creative and engineering design process skills stand out as indispensable competencies in the 21st century. Teaching methodologies across disciplines strive to cultivate critical thinking for effective problem-solving. A problem-solving-centered approach to teaching, employing active learning methods, has emerged as a prominent strategy to equip students with these vital skills. Utilizing the creative and engineering design process skills method has proven instrumental in enhancing students' abilities and academic performance.

For instance, research conducted by Saksuparb (2021) demonstrated that employing the creative and engineering design process skills method led to a significant increase in problem-solving proficiency among Grade 10 students, surpassing that of the control group. Similarly, Wittawin, Suphawan, and Araya (2017) found that implementing STEM education in Physics, focusing on topics like sound waves for Grade 11 students and motion for Grade 10 students, resulted in substantially higher learning achievements compared to standard criteria.

Furthermore, Sriwibunrat and Onthenee (2019) observed significant improvements in problem-solving skills among Grade 4 students in Physics, particularly in the topic of work and energy, with STEM education. Similarly, Noiwong and Wongthong (2020) emphasized the integration of STEAM education to enhance problem-solving skills, particularly in engineering design, with a focus on topics such as Soilless Culture or hydroponics, benefiting primary school students.

Moreover, Wongthong (2019) highlighted the efficacy of STEAM education in fostering critical thinking among students in a small primary school setting. The study revealed that students were able to integrate various skills such as observation, data collection, identification, and problem-solving effectively, leading to significant improvements in their learning achievements.

These findings underscore the pivotal role of creative and engineering design process skills, as well as the effectiveness of innovative educational approaches such as STEM and STEAM education, in nurturing problem-solving abilities and empowering students for success in the dynamic landscape of the 21st century.

Learning achievement serves as a crucial yardstick for assessing students' success in mastering the subject matter within the school curriculum. It enables educators to gauge their students' potentials, thereby facilitating targeted and efficient teaching methods aimed at student development (Intavimolsri, 2017). Learning achievement, often tailored to individual students, can be quantified through assessments such as learning achievement tests (Phunphon, 2019). Generally, it serves as a reliable metric for measuring students' progress and success, albeit through methods that can be intricate and time-consuming, such as observation and achievement tests.

In the realm of STEAM education, a study conducted with Grade 9 students from Wangtako Community in Chumphon Province utilized a comprehensive assessment comprising 40 multiple-choice questions, aligning with Bloom's taxonomy categories to measure cognitive domains: Knowledge, Comprehension, Application, Analysis, Evaluation, and Synthesis. The results demonstrated a significant increase in learning achievement, surpassing predefined criteria with statistical significance (Pholmool, 2015). Furthermore, STEAM education has been shown to foster essential life skills among Grade 7 students, leading to a notable enhancement in their learning achievement. Additionally, research findings indicate that STEAM education positively impacts learning achievement, creativity, and satisfaction levels among Grade 6 students (Pinitmontree, 2018).

Research about STREAM Education in Thailand

Numerous research groups, educators, and teachers have embraced STREAM education in their research and classrooms. However, despite its widespread utilization, the application of STREAM education specifically in the Motion topic remains scarce.

STEAM education, on the other hand, has been effectively employed in various contexts. For instance, it has been instrumental in cultivating environmental conservation attitudes among Grade 9 students from Wangtako Community in Chumphon Province and in developing life skills among Grade 7 students (Pinitmontree, 2018). Khummanee (2018) innovatively utilized STEAM in developing medication games to foster creativity and innovation skills among vocational innovators. Thananthong and Dornbundit (2018) successfully integrated STEAM with the 5E inquiry learning model to enhance high school students' learning achievements in chemical reactions.

Moreover, STEAM education has been shown to nurture creativity (Chanthong, 2019; Buaphan, Jaradrawiwat & Jenjit, 2020; Klubsakun & Phonak1, 2020) and engineering design skills (Noiwong & Wongthong, 2020), particularly in topics like Soilless Culture or hydroponics, catering to primary school students. It has also been applied in technology projects among Grade 10 students (Subcharoen, Tungkunanan & Kantathanawat, 2020) and in developing critical thinking skills among Grade 1 students in small schools (Wongthong, 2019). Additionally, STEAM education has been utilized to enhance scientific and technological skills through inquiry-based teaching methods among Grade 9 students at Suphannapoom School in Suphanburi (Meesangphan & Kitroongrueng, 2020).

In these examples, STREAM education has been effectively integrated into various disciplines such as science, chemistry, and technology, often incorporating gamification to bolster students' 21st-century skills and enhance their learning of creative and engineering design process skills.

METHOD

The research methodology employed in this study adopts a one-group pre-test post-test design. The sample consisted of 39 Grade 8 students enrolled in the first semester of the 2021 academic year at Hatyai Ratprachasun School, located in Songkhla province, Thailand. These students were purposefully selected due to their direct association with the first author as their instructor and registered to learn the Motion topic.

Data collection

Five lesson plans focusing on the Motion topic for Grade 8 students were meticulously crafted utilizing the STREAM education framework. These comprehensive lesson plans collectively spanned 25 teaching hours. To ensure their efficacy and alignment with educational objectives, a panel of five experts was convened to validate the lesson plans. The Index of Item-Objective Congruence (IOC) was calculated for each plan, revealing IOC values ranging from 0.80 to 1.00, indicating an acceptable or qualified level of alignment.

Subsequently, the experimental group, instructed using the aforementioned STREAM education lesson plans, underwent assessment via two tests: the Learning Achievement Test and the Engineering Design Process Test. The Learning Achievement Test comprised 40 multiple-choice questions pertaining to the Motion topic, while the Engineering Design Process Test encompassed questions structured around four distinct STREAM situations.

Data analysis

The students' learning achievement and engineering design process scores were computed for both mean and standard deviation (SD). The normal distribution of students' learning achievement and engineering design process scores was checked by using Shapiro-Wilk test before launching a paired-samples t-test, which was conducted to examine the disparities between students' learning achievement and engineering design process skills before and after the implementation of the STREAM lesson plans in the Motion topic. The level of statistical significance was set at 0.01.

FINDINGS AND DISCUSSION

The impact of STREAM lesson plans on Grade 8 students' learning achievement in the Motion topic can be shown as Table 2.

Table 2
Students' develoment of the learning achievement (n = 39)

Test	Mean	SD	*t*	Sig
Before	17.23	4.19	19.44	.000**
After	32.34	2.44		

Table 2 illustrates that the learning achievement scores of students before and after engaging with the developed learning management plans were 17.23 and 32.34, respectively. The results of the t-test indicate that the learning achievement score after utilizing the developed learning management plans significantly exceeded the pre-implementation score, demonstrating a statistical significance level of .01. This notable improvement can be attributed to the students' active participation in hands-on activities and utilization of locally accessible materials to create their own work pieces, facilitating enhanced learning outcomes.

These findings align with the research conducted by Krapaothong (2018) who developed STEAM learning activities for Grade 10 students and found that STEAM learning activities resulted in a significant increase in students' learning achievement and creativity related to life and environment. Moreover, STEAM integrated with e-Learning for Technology 1 (computing science) students, led to a noteworthy improvement in student's learning achievement. Similarly, Buaphan et al. (2020) utilized STEAM learning activities and observed a significant enhancement in Grade 4 students' learning achievement, creativity, and attitude towards learning. These studies collectively underscore the positive impact of STEAM education on learning achievement across various educational contexts and grade levels, validating its effectiveness in fostering holistic learning outcomes. In addition, this study affirms that STREAM education, which is extended from STEAM education, still be effective in promoting students' learning achievement.

The impact of STREAM lesson plans on Grade 8 students' creative and engineering design process skills in the Motion topic can be shown as Table 3.

Table 3
Students' develoment of creative and engineering design process skills (n = 39)

Test	Mean	SD	*t*	Sig
Before	15.66	3.96	25.85	.000**
After	31.54	2.59		

Table 3 presents the creative and engineering design process skills scores of students before and after engaging with the developed learning management plans, which were 15.66 and 31.54, respectively. The results of the t-test indicate a statistically significant increase in the creative and engineering design process skills score after utilizing the STREAM lesson plans, with a significance level of .01. This enhancement can be attributed to the integration of science, technology, religion, engineering, art, and mathematics or STREAM, which positively influenced the students' creative and engineering design process skills as well as their learning process.

Upon observation, it was noted that students exhibited remarkable creativity and proficiency in producing work pieces adorned with vibrant colors. They demonstrated the ability to generate ideas and construct equilibrium objects integrating principles from religion, art, and STEM. Notably, students crafted models of birds in equilibrium states, balancing the weight of the wings with model clay. Utilizing everyday materials, they explored various designs, showcasing their problem-solving abilities. When integrating Art into STEM, students utilize their aesthetics to apply various colors in decorating the equilibrium bird model. In addition, the students stated some positive effects of STREAM learning unit of the Motion topic on their moral and ethics such as unity, cooperation, empathy, perseverance, etc.

These findings resonate with Wongthong's (2019) study on the use of STEAM Education to cultivate critical thinking and problem-solving skills among primary students in a small school. Wongthong found a significant increase in the average score of students, from 30.46% to 47.85%, with a statistical significance level of .05, although it remained below the predefined standard of 60%. Similarly, Noiwong and Wongthong (2020) utilized STEAM education to develop engineering design skills among primary school students, focusing on the topic of Soilless Culture or hydroponics. The study revealed that students effectively solved problems and selected suitable methods, showcasing the efficacy of STEAM e1ducation in fostering practical problem-solving skills. In addition, it can be concluded that STREAM education, which is extended from STEAM and STEM education also yields positive impact on students' creative and engineering design process skills. As Puchongprawet and Chantraukrit (2022) found that STEM education yielded a positive effect on students' problem-solving and creativity.

CONCLUSION AND SUGGESTIONS

The innovative STREAM education model seamlessly integrates Religion and Art into existing STEM education, aiming to imbue projects with beauty and religious values. This integration not only enhances aesthetic appeal but also stimulates students' creativity, drawing their attention and fostering deeper engagement with the learning process. Educators already proficient in STEM education can readily incorporate Religion and Art into their classrooms, tailoring learning management plans to suit the specific contexts of their schools and communities. Well-designed STREAM learning plans have the potential to significantly enhance students' learning outcomes.

Introducing STREAM into classrooms offers opportunities to diversify learning activities within the Motion topic and extend its application to other subjects and educational levels. By integrating Religion (R) and Art (A) with STEM, STREAM promotes students' aesthetic appreciation in learning, enriching their educational experience. While science students may initially find the transition to STREAM unfamiliar, teachers can gradually introduce the concept, starting from simpler concepts and gradually progressing to more complex ones until students become accustomed to the STREAM approach.

Looking ahead, there is a compelling need to promote the adoption of STREAM education more extensively across Thailand. By embracing STREAM, educators can create dynamic learning environments that inspire creativity, critical thinking, and holistic development among students, preparing them to thrive in an increasingly interconnected and interdisciplinary world.

In future research, a more robust experimental design, such as quasi-experimental research, may be needed to strengthen the findings on the effects of STREAM education on students' development of desirable attributes. In addition, a case study can be conducted to provide more in-depth findings to complement the experimental research.

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