

The Development of Science Learning Activities by Applying the STEM Education Model to Promote Student Creativity

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Abstract

This research aimed to design and evaluate science learning activities using the STEM education model to foster creativity among students. Employing a type I developmental methodology, the study was structured into two primary phases: development and evaluation. In the development phase, contemporary educational challenges were identified, leading to the formulation of STEM-based learning activities, which were then tested with a select group of students. For the sample, a distinct student group participated in these STEM activities, with their creativity and satisfaction becoming the central assessment metrics. Results revealed a formulated STEM education model with five essential steps: introduction, problem identification, information gathering, solution design and implementation, and presentation. Following the activities, students' creativity scores averaged at 86.16%, surpassing the target of 80%. Additionally, satisfaction feedback indicated a high average rating of 4.65. To conclude, the customized STEM education model effectively heightened creativity among students, evident from their elevated creativity scores and significant satisfaction rates. Recommendations from this study urge schools and educational institutions to adopt this STEM education model due to its demonstrated efficacy in boosting student creativity and satisfaction, offering a structured methodology to tackle existing educational challenges and stimulate innovation.

Keywords: *STEM education; creativity; satisfaction, Science learning, Assessment metrics.*



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INTRODUCTION

A person in the 21st century must have high-level thinking skills. can solve problems have a critical point of view Be open to innovation, and be productive, creative, and collaborative (Kay, 2010). Therefore, the need for scientific and technological development to adapt to these changes is increasing rapidly. These demands necessitate the reform of current guidelines required by countries' education systems (Becker & Park, 2011).

One of the important skills for educational management in the 21st century is creative thinking. (Atthachakara, S, 2021) Creativity is a key factor in scientific discovery. Scientists use creativity to create solutions using knowledge in the science classroom. Students must use creativity in finding solutions, leading to inventions and innovations. (Kim KH, 2011)

In Thailand, the government launched a new "Thailand 4.0" policy in 2016 to mark the significant

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DOI: <https://doi.org/10.33830/ijrse.v5i1.1345>

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shift of the country's economy to a value-based or innovation-driven economy. by focusing on technology Creativity. (National Economic and Social Development Plan). However, Thai students are still not creative. Seen from learners tend to remember knowledge related to the lesson. Learners are unable to generate and present their ideas for solving problems. The creative development process can be achieved through the use of appropriate learning management. One of the effective learning management processes is STEM education is a student-centered approach to teaching and learning that allows learners to express their opinions, practice, and interact in the classroom. Emphasis on encouraging students to think about the process and take action to allow learners to use new ideas and train learners to express their thoughts freely. and a variety of formats.

STEM education is popular all over the world, including in Thailand. Institute for the Promotion of Teaching Science and Technology. (IPST) It was the first organization to adopt a STEM approach to Thai science teachers in 2016 to achieve the "Thailand 4.0" policy (Vasquez JA, Sneider C and Comer M 2013) for that reason, the researcher is therefore interested in conducting research to develop science learning activities by applying the STEM education model. to promote creativity Focusing on students practicing various activities to find answers by themselves. independent thinking has been brainstormed to exchange knowledge and ideas with each other to develop the creative potential of students which aims to develop learners with the 4 characteristics of thinking, namely active thinking, initiative, flexible thinking, and meticulous thinking. This is to bring the research results obtained to develop the learning management process for further benefits.

LITERATURE REVIEW

This section has been structured into topics consistent with the research objectives. It is literature that shows the link between the main ideas of the research.

STEM and Creativity

The National STEM Center defined STEM education as an educational management approach for students to learn and integrate the knowledge of science, technology, and engineering processes. and mathematics to connect and solve real-life problems, including developing new processes or products and developing 21st-century skills. STEM education is learning through activities or projects that integrate science, mathematics, technology, and engineering design processes. The students will be able to do activities to develop knowledge and understanding and practice skills in science, mathematics, and technology and apply knowledge to design works or methods to meet needs or solve problems related to daily life. to obtain technology that is a product of the engineering design process. (The National STEM Center, 2014)

Institute for the Promotion of Teaching Science and Technology defined the meaning of STEM education as It is an educational approach that integrates science, engineering, technology, and mathematics, emphasizing knowledge to solve problems in real life Including the development of new processes or products that are beneficial to life and work. (Institute for the Promotion of Teaching Science and Technology, 2015)

Should improve students' critical thinking skills. This could occur as a result of activities pressured out in learning which are more oriented to students' participation, which could also encourage students to reflect critically. Thus, using the PjBL STEM (Science, Technology, Engineering, and Mathematics) model can assist students in enhancing their critical thinking skills. It motivates students while also demanding them,

according to Capraro et al. (2013, in Africana et al., 2016), because it trains them to analyze, think critically, and strengthen higher-level thinking skills.

STEM provides opportunities for learners to comprehend the significance of integrating various areas of study and their personal applications in learning through its implementation. As a consequence of the implementation, students can enhance their own logical thinking. In line with it though, STEM can assist students in increasing their capacity to address any problem which is presented and overcome it using critical thinking. According to a different viewpoint expressed (Murnawianto et al. 2017)

The STEM framework has objectives that correspond with the characteristics of 21st-century education, among which are critical thinking skills, or thinking that is always curious about the information available to achieve a thorough understanding. As a result, learning using the STEM approach can assist students in enhancing their ability to think critically. According to (Yanuar 2018)

STEM refers to Science, Technology, Engineering, and Mathematics (Reeve, 2013 in Yanuar, 2018; Devi et al., 2018; and Toto, 2019)

Guilford defines creativity as the ability of the brain to “think in many directions” or “multifunctional thinking” and that creativity is composed of Fluency in thinking, flexible thinking, and their own ideas, especially those who have such characteristics, must be the ones who dare to think Not afraid to be criticized and have the freedom to think as well. (Guilford, 1959: 115)

Torrance states that creativity is the ability of a person to create products. or new strange things that were not known before which things These may be caused by the combination of various knowledge. gained from experience and connected to new situations Something that happens but is not absolutely necessary. which may come out in the form of artistic, literary, and scientific outputs. (Torrance, 1962: 16)

Taylor's theory This has the idea that creative works It doesn't have to be superlative, meaning there's no need to research new things that no one has thought of before or create new theories. human creativity. (Taylor, C. W., & Holland, J., 1964)

Creativity is the ability to go beyond traditional ways of thinking in order to develop new and original ideas, methods, or objects. In the view of Gardner and Weinstein. (Gardner and Weinstein, 2018)

Creativity is the ability to imagine objects that are not real while forming pictures in the mind of things that one has not seen or experienced and turning pictures into real situations. In cases where creativity is enhanced, learners express and cope with feelings, which in turn foster mental growth by providing opportunities for trying out new ideas and innovative ways of thought processes. Therefore, Yates and Twigg. (Yates and Twigg, 2017)

RESEARCH METHOD

This research is a type I developmental research (Richey and Klein, 2007) which focuses on innovation design and development, divided into 2 phases: the development process and the evaluation process. Evaluation Process), in phase 2 of this research, develops science learning activities by applying the STEM model. show details as follows.

Phase 1 Development Process

1. Study the current learning management problems and the need for science learning activities. The development of learning management activities by applying the STEM education model
2. Design learning management activities by applying STEM education knowledge. Take the information obtained from the study. problems of creativity to develop a learning management plan and tools used to collect data. After that, it will be examined by 3 experts.

3. Experiment with the learning management plan by applying the STEM education model. and the experimental group, 25 students, the academic year 2022, was obtained by purposive sampling of 2 plans and using the creativity test.

Phase 2 Evaluation Process

Organized learning activities by applying the STEM education model for 2 plans with students. After organizing the learning management activities by applying the STEM education model, the creativity test was used. For the students with a sample group of students Including having students complete a satisfaction assessment questionnaire for learning activities by applying the STEM education model.

Research tools

Learning management plans by applying the STEM model, 2 plans with a total time of 4 hours have been evaluated for the appropriateness of the learning management plans. The average expert opinion score was 4.67, which was the most appropriate level. Creativity Quiz For students, 4 items passed, finding the IOC value equal to 0.83. Satisfaction questionnaire of 15 items with a 5 -level estimating scale that passed the IOC value of 0.91.

Data analysis

Finding the appropriateness of the learning management plan by using basic statistics, namely the mean, then the average that has been interpreted as a level of suitability as follows the average score ranges from 4.51 – 5.00 means most appropriate, 3.51 – 4.50 means very appropriate, 2.51 – 3.50 means moderately appropriate, 1.51 – 2.50 means less appropriate, 1.00 – 1.50 means least appropriate.

Analyze the data from the creativity measurement form obtained from the measurement after the end of the learning activities by finding the mean, percentage, and standard deviation. If the learner gets 80 percent pass the criteria, if less than 80 percent does not pass the criterion.

Student satisfaction score takes the average and standard deviation The average was taken to find the satisfaction level of 5, which is an average score ranging from 4.51 – 5.00 means most appropriate, 3.51 – 4.50 means very appropriate, 2.51 – 3.50 means moderately appropriate, 1.51 – 2.50 means less appropriate, 1.00 – 1.50 means least suitable.

FINDINGS AND DISCUSSION

Subject research the development of science learning activities by applying the STEM education model to promote the creativity of the students.

1. The results of the development of science learning activities by applying the STEM education model for students.

The researcher synthesized the learning management concepts of 5 educators and researchers, namely, the learning management concept of STEM education by Somchai Unkaew. (2018) Guilford's theory of cognitive structure (Guilford, 1956) Torrance's Theory of Creativity (Torrance, 1962) Uta Theory

(AUTA, 1983) and the theory of creating self-knowledge by constructing works (Constructionism) of Thitana Khaemamane. (2011) led to the design of science learning activities by applying the STEM education model consisting of 5 steps as shown in Table 1.

Table 1 presents the process of organizing science learning activities by applying the STEM education model by developing the concept of learning management for STEM education of Somchai Unkaew. (2018)

The Process of Organizing Learning Activities by Applying the STEM Education Model consists of 5 steps.	Teaching method	Creativity	Instructor role
<p>Step 1: Encourage introduction to the lesson. It prepares students before starting school. to know what they are learning to Motivate learners to be interested in learning by using games.</p> <p>(Guilford's Theory in the 1st Dimension)</p>	<p>1. The students join together to play an alert game, counting numbers, and pointing fingers to practice concentration and mindfulness before class starts.</p> <p>2. The teacher let the students play a Bingo game on the separation of mixtures.</p>	<p>Fluent Thinking</p>	<p>Coach Facilitator</p>
<p>Step 2 Identify the problem. Students must identify the problem by considering the problem or sub-activity that must occur in order to form a solution. to resolve such problems.</p> <p>(Torrance's theory and Guilford's theory)</p>	<p>1. Students jointly study the situation of the mixture prepared by the teacher. Teachers and students work together to identify problems. how to make the mixtures that the students studied Best separated from each other.</p>	<p>Originality</p>	<p>Coach Facilitator</p>
<p>Step 3 Gather information and ideas related to the problem. Students collect information and concepts related to solving such problems. In search of related ideas, there is an action. (Torrance's Theory and Guilford's Theory)</p>	<p>1. Have students divide into groups of 4 students, then have students collect information and concepts related to solving the problem. by searching from media and various learning sources such as textbooks, related books, and internet media</p>	<p>Thoughtfulness</p>	<p>Facilitator co-learner</p>
<p>Step 4 Design the solution / Implement the solution. apply the accumulated knowledge to design a method Define an element of a method or output. Then proceed to solve the problem. (Guilford's Theory and Theory of Self-Knowledge through Creation)</p>	<p>1. Each group of students worked together to design and implement a solution to the identified problem. by making a work of art</p> <p>2. When the fabrication is completed, proceed to solve the identified problems.</p>	<p>Originality</p>	<p>Facilitator co-learner</p>
<p>Step 5 Present After solving the problem or the result until it has the desired performance. The problem solver must present the</p>	<p>1. Have each group of students present their invention. And explain the steps to solve the problem</p>	<p>Originality</p>	<p>Coach</p>

The Process of Organizing Learning Activities by Applying the STEM Education Model consists of 5 steps.	Teaching method	Creativity	Instructor role
results. They need to design a way to present information that is easy to understand and interesting. (Gilford's theory in the 3rd dimension)	correctly. class page 2. Students join together to exchange knowledge in the work together.		

From Table 1, the researcher has synthesized the learning management concepts of 5 educators and researchers, namely Somchai Unkaew's STEM education learning management concept (2018), and Gilford's cognitive structure theory. (Guilford, 1956), Torrance's Creativity Theory (Torrance, 1962), U-TA Theory (AUTA, 1983), and the theory of self-knowledge by constructionism (Constructionism) of Tana Kaemamane. (2011) led to the design of learning activities by applying the teaching model of STEM education, consisting of 5 steps: 1) encourage introduction into lessons 2) identify problems 3) gather information and concepts related to the problem, 4) design a solution/implement the solution, and 5) present it. Then use the synthesized science learning activities to create a lesson plan.

2. The effect of promoting creativity by using science learning activities by applying the STEM education model for students, who pass the criteria of 80 percent.

The result of analyzing the creative skills scores of students in schools in Kalasin Province. After using science learning management by applying the STEM education model shown in Table 2.

Table 2 The results of the assessment of creativity of students after using science learning activities by applying the STEM model. 80 percent criteria.

Assessment Items	Average	Standard Deviation	Percentage	80 Percent criteria
1. Fluent thinking	3.50	0.5	87.50	Pass
2. Flexible thinking	3.50	0.5	87.50	Pass
3. Originality	3.36	0.48	83.93	Pass
4. Detailed thoughts	3.43	0.49	85.71	Pass
Average total	3.45	0.49	86.16	Qualify

Table 2 shows the results of the assessment of creativity the students after using science learning activities by applying the STEM education model. It was found that overall students had an average score of 3.45. is 86.16 percent of the full score, which passes the set criteria, which is 80 percent in all 4 areas.

3. The results of a study of satisfaction with science learning activities by applying a STEM education model to students

Table 3 The results of the analysis of the satisfaction of students who received science learning activities by applying the STEM education model.

Clause	Assessment Items	Average	Standard Deviation	Level of Satisfaction
Atmosphere				
1	Teachers encourage students to come up with innovative ideas	4.64	0.61	the most
2	The teacher gives students the opportunity to do activities independently	4.43	0.82	a lot
3	The teacher gives students the opportunity to ask questions during class	4.21	0.86	a lot
4	Teachers have interesting and innovative teaching materials	4.79	0.56	the most
5	Teachers encourage students to take initiative and to be critical	4.57	0.73	the most
Total Average Atmosphere		4.53	0.72	the most
Learning activities				
1	Students are fully involved in activities	4.93	0.07	the most
2	Teachers have to give advice to students in doing activities	4.71	0.35	the most
3	Teachers can apply what they teach to social and environmental conditions	4.29	0.92	a lot
4	Teachers are preparing to teach. (Considering the media, various devices are ready)	4.93	0.07	the most
5	Teachers encourage students to exchange knowledge and ideas	4.79	0.17	the most
Total average of learning activities		4.73	0.31	the most
Benefits				
1	Students understand the content and can memorize it	4.43	0.96	a lot
2	Students can build knowledge and self-understanding	4.36	0.80	a lot
3	Students come up with a variety of ideas and	4.79	0.31	the most

	can-do activities freely			
4	Students are happy and having fun in learning activities	5.00	0.00	the most
5	Students can apply the knowledge gained in their daily lives	4.93	0.07	the most
Total average benefits received		4.70	0.43	the most
Total average of all 3 aspects		4.65	0.49	the most

From Table 3, it was found that students were satisfied with the science learning activities by applying the STEM model. To promote creativity, including all 3 aspects, at the highest level. The average score for all 3 aspects was 4.65 when considering each aspect, in descending order of average scores, namely learning activities, an average score of 4.73, benefits received, an average score of 4.70, and atmosphere, an average score of 4.53, respectively. that the students had the highest level of satisfaction in 3 items in descending order of scores, students are happy, having fun from learning activities, an average score of 5.00, teachers are preparing for teaching (media, equipment, tools are ready), an average score of 4.93, and students can apply the knowledge gained. on a daily basis, with an average score of 4.93 respectively.

CONCLUSIONS

The researcher has summarized the research results according to the objectives as follows:

1. Create science learning activities by applying the STEM education model, totaling 2 plans, totaling 4 hours, namely Learning Management Plan 1 on Simple Separation of Substances, 2 hours' time, Learning Management Plan 2 on Separating Mixtures, time. 2 hours.
2. To promote creativity for the students, the average scores were 1) Fluency, an average score of 3.50, representing 87.50 % 2) Flexible thinking, an average score of 3.50, representing 87.50 % 3) Originality, an average score of 3.36, representing 83.93 % 4) Thoughtfulness, the average score is 3.43, equivalent to 85.71 percent. The average score in all aspects is 3.45 out of 4 full scores, equivalent to 86.16 percent, which is higher than the criteria set at 80 percent. showed that after using science learning activities by applying the STEM education model Students had scores for both individual and overall creativity. pass the criteria of 80 percent. Showed that after using science learning activities by applying the STEM education model Students had scores for both individual and overall creativity. pass the criteria of 80 percent.
3. To study the satisfaction with science learning activities applying the STEM education model. The students were satisfied with the science learning activities by applying the STEM education model. To promote creativity, including all 3 aspects, at the highest level. The average score for all 3 aspects was 4.65 considering each aspect. In order of the highest average score, the learning activities average score was 4.73, the benefits received an average score of 4.70, and the atmosphere received an average score of 4.53, respectively. Items in descending order of scores were students happy and having fun from learning activities with an average score of 5.00. Teachers were prepared to teach. (Media devices are ready), the average score is 4.93, and the students can apply the knowledge to be applied in daily life, the average score is 4.93, respectively.

LIMITATIONS & FURTHER RESEARCH

Limitations in doing this Research

1. Time constraints for the event
2. Unfavorable location restrictions
3. Insufficient media and equipment limitations

Suggestions for further research

1. Should study the organization of a variety of learning activities. to develop the creativity of students in other subjects and at higher grade levels to be suitable for the environment of the learners
2. Research on science learning activities using STEM education should be studied. To develop other 21st centuries skills such as teamwork skills communication skills and analytical thinking skills, etc.

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