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DEVELOPMENT OF TEACHING MODEL BASED ON STEAM EDUCATION CONCEPT COMBINED WITH INTEGRATED TEACHING TO PROMOTE CREATIVE THINKING SKILLS FOR INNOVATIVE INTEGRATED AGRICULTURAL TECHNOLOGY

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ABSTRACT

This study was to develop teaching model based on STEAM education combined with integrated teaching, investigate an effect of using the teaching model based on the concept of STEAM education combined with the integrated teaching, and promote creative thinking skills for innovative integrated agricultural technology of Nakhon Sawan Rajabhat University students. The sample group consisted of 21 students who registered for the course Sustainable Agriculture and Smart Consumption in the first semester of the academic year 2024. They were obtained by simple random sampling (drawing). A single-group pre-test/post-test design was employed. This research and's development comprised six steps: 1) identifying the problem, 2) exploring related concepts, 3) designing a solution method, 4) developing, 5) presenting, and 6) evaluating. Data were analyzed using descriptive statistics and a paired-samples t-test to compare pre-test and post-test knowledge scores. Findings showed that the students had a higher level of knowledge than before with a statistical significance level at .001. It was found that the students had a highest level of skills in creative thinking ($\bar{x}$ = 3.37, SD = 0.58 on a 4-point scale) and they had a high level of satisfaction with the teaching model ($\bar{x}$ = 4.30, SD = 0.46 on a 5-point scale). This implied that the teaching model could be used for developing knowledge and skills in creative thinking for innovative integrated agricultural technology of Nakhon Sawan Rajabhat University students. Limitations include the small sample size, which may limit the generalizability of the findings.

Keywords: STEAM education, Creative thinking, Integrated teaching, Agricultural technology

I. INTRODUCTION

There was the announcement of the Ministry of Higher Education, Science, Research and Innovation on the desired skills of the workforce in the field of modern agriculture, 2002. In other words, it was the desired skills of modern agriculture entrepreneurs using technology and management for modern agricultural business operations and sustainability based on production problem solving by using innovation and technology (Announcement of the Ministry of Higher Education, Science, Research and Innovation on the Desired Skills of Workforce in Modern Agriculture, Digital Marketing, and New Forms of Tourism B.E. 2565, 2024: pp. 16-24). Hence, curriculum design and teaching/learning facilitation must be up-to-date. In fact, it is essential that effective citizen preparation in the 21st century be practiced. This is because the social changes that have occurred have had profound effects on the way of life of society. Importantly, the most important skill is learning skill that leads to establishing a conceptual framework and key strategies for managing learning in interdisciplinary content or topics for the 21st century. This can be done by promoting understanding of subject matter and integrating skills into all subjects, e.g. skills in learning and innovation, information technology, life and occupation, thinking, etc. (Tuntirojanawong, 2017, p. 2845).

The concept of STEAM education is a guideline for teaching/learning facilitation which five fields of study are integrated: Science, Technology, Engineering, Arts and Mathematics. It aims to develop analytical thinking, problem solving and all-round creativity of learners. As a matter of fact, STEAM education focuses on the learner to practice in the actual situation or through diverse activities such as creating experimental works and project design. This truly helps the learner be able to connect knowledge from many disciplines that can be used effectively in the real life. Besides, it promotes good attitude towards learning; particularly on science and technology as an important foundation for the country development in the 21st century (Choeichaeng, et al., 2022, pp. 70-78).

Furthermore, there is a report on use of STEAM education to develop creative thinking of secondary school students (Chanthong, 2019, p. 15; Chanintarapum, 2020, p.19; Hemkaew, 2025, p. 12) Education and local wisdom-based for education students. In this respect, the efficiency value was 8.00/86.92 higher than the 75/75 criterion with a significant level. The capability in learning design and creative skill after learning way higher than before with a significant level. Meanwhile, a level of awareness of local wisdom values before and after learning was different with a statistical significance level ($p<0.01$) (Nakwijit, 2020, pp. 220-224)

In this research, the objectives of this study were to: 1) develop teaching model based on STEAM education combined with integrated teaching; 2) investigate an effect of using the teaching model based on the concept of STEAM education combined with the integrated teaching; 3) promote creative thinking skills for innovative integrated agricultural technology of Nakhon Sawan Rajabhat University students.

II. LITERATURE REVIEW

Educational facilitation in the 21st century is now facing structural change at a global level which focuses on the creation of "A human being with all-round abilities". This is to cope with a rapidly changing world in terms of technology, economy and society. One of the most widely accepted and driven approaches is STEAM education. It is the integration of five aspects: science, technology, engineering, arts and mathematics as an important foundation of skill development in the 21st century. It includes analytical thinking, problem solving, systematic thinking and learning by doing. It can be observed that the learner do not study subjects separately as in the old system, but rather practices integrating knowledge to solve problems or create works in real situations. This is through projects or activities focusing on creative thinking and engineering thinking. Later on, South Korea, one of the educational development leaders, puts the importance on the dimensions of culture, languages and arts. Thus, STEAM education is developed by adding arts leading to STEAM education. This emphasizes on the development of learners to have a balance of both reason and emotion. It also promotes imagination, creative thinking and effective communication which are the heart of innovation in the digital age (Jaradrawiwat, 2017, pp. 21-25).

Furthermore, development of the learner focuses on the study of learning development theory of Bloom. He devised learning objectives into three aspects: 1) Cognitive Domain, 2) Affective Domain, and 3) Psychomotor Domain. All of these are used for Pre-test/Post-test design to distinguish knowledge, thought and intelligence into different levels. In addition, it helps adjust content, searching for techniques and methods, and organizing teaching/learning activities that are appropriate for learners to promote their potential development as set (Bloom et al., 1956; Anderson et al., 2001, p. 67). Existing Bloom's Taxonomy is improved to be appropriate with learning in the 21st century. That is, there is a shift from knowledge-based learning to thinking-based learning (Cognitive processes). This consists of six levels: 1) remember, 2) understand, 3) apply, 4) analyze, 5) evaluate and 6) create. Particularly, the "create" level is emphasized as the highest point of learning. This is because it is a process which the learner can combine body of knowledge, skills and experience together in order to create concepts, methods or new meaningful or worthwhile works. Meanwhile, Amabile (1996, pp. 115-117) proposed theory of components of creativity divided into internal personal component (i.e. domain-relevant skills or expertise reflecting knowledge and skills related to creativity relevant processes or creativity skills). It covers intellectual methods, problem-solving, strategies and personal characteristics such as flexibility, tolerance, and risk taking. It includes task motivation which an internal driving source that directly influences creative efforts. Meanwhile, external personal components such as social environment which can promote or hinder the creative process of an individual. Thus, creative thinking does not occur from only one factor, but it is the sum of a complex system of elements. In fact, Amabile puts the importance on novelty and usefulness as important true indicators of creative works. In addition, creative thinking consists of two principles problem exploring and problem solving. Hence, creative thinking needs various skills and existing thinking must always be adjusted. Indeed, innovation is built on creativity, which is a fundamental element of corporate innovation. That is, creativity is used within an organization in order to be successful. In general, innovation is different from creativity because it focuses on the application in economic environment. Hence, the relationship between creativity and innovation can be

viewed from two perspectives: the first one seen creativity as the creation of ideas, while innovation as the application of ideas. The second one is the combination of both creativity and innovation together. This is, creativity is the initial step of innovation process. So, creativity is the idea component of innovation and innovation covers the application and new ideas or concepts (Peerapan et al., 2023, p. 309). Therefore, the researcher anticipates that first-year students who receive instruction through an integrated STEAM-based teaching model will exhibit increased creative thinking skills in innovative integrated agricultural technology.

III. RESEARCH METHODOLOGY

Conceptual Framework

According to the research, concepts and theory as mentioned, the researcher set a conceptual framework of this study. It comprised six steps of learning experience management:1) problem identifying, 2) exploring related concepts, 3) problem solving design method, 4) developing, 5) presenting, and 6) evaluating (Figure 1)

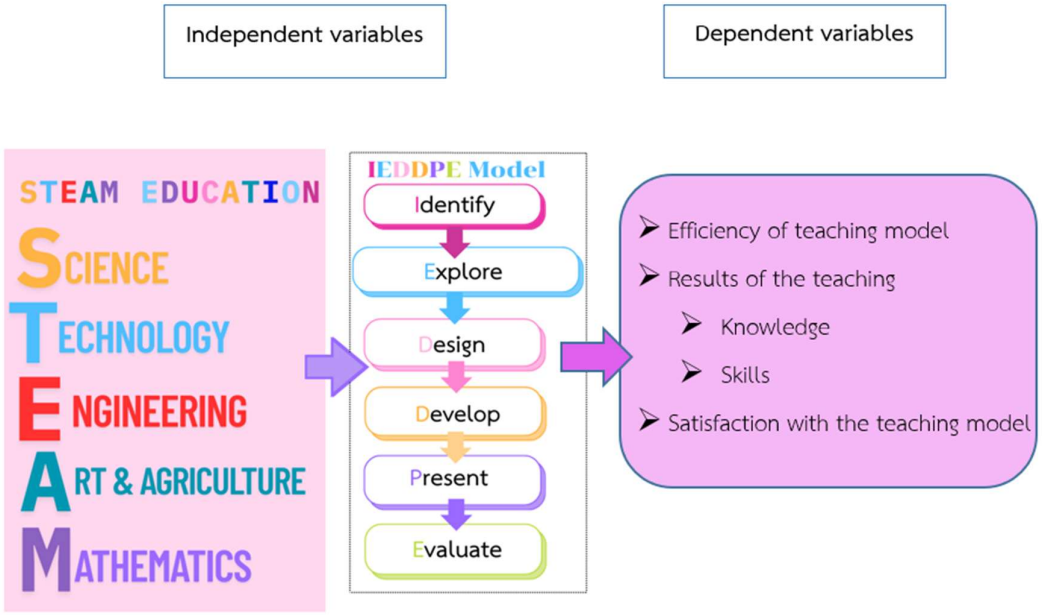


Figure 1: Conceptual framework

Based on the conceptual framework, three hypotheses were developed to achieve the research objectives: (1) the efficiency (E1/E2) of the developed teaching model integrating STEAM (Science, Technology, Engineering, Art & Agriculture, Mathematics) and the IEDDPE process would meet or exceed the predetermined criterion (80/80); (2) students' learning outcomes in terms of knowledge and skills after learning through the IEDDPE teaching model would be significantly higher than their outcomes before learning ($p < .05$); and (3) students would demonstrate a high level of satisfaction with the teaching model based on STEAM and the IEDDPE process. This study followed a Research and Development (R&D) framework, beginning with the systematic development and validation of the

integrated STEAM teaching model and its assessment instruments. A quasi-experimental one-group pretest-posttest design was then employed to evaluate the model's effectiveness by measuring significant changes in students' knowledge and creative thinking skills resulting from the intervention.

Population and Sample Groups

The population in this study were Nakhon Sawan Rajabhat university students who registered the course "Sustainable Agriculture and Smart Consumption" in the first semester of the academic year 2024 (7 sections or 151 students). The sample group consisted of one section or 21 students obtained by simple random sampling.

Research instruments

The research instruments included: (1) an integrated STEAM learning unit and learning management plan on integrated agricultural technology, (2) a knowledge test, (3) an evaluation form assessing creative skills for integrated agricultural technology and innovation, and (4) an evaluation form measuring students' satisfaction with the teaching model.

Quality control of research instruments

1. Development of integrated STEAM learning unit learning facilitation plan on the topic of integrated agricultural technology. It had the following steps to create:

1.1 Studied the characteristics of the learning management. Also, studied the General Education curriculum of Nakhon Sawan Rajabhat university (Course: Sustainable Agriculture and Smart Consumption). The topic was "Integrated Agricultural Technology: A Guideline for Creating the Learning Facilitation Plan".

1.2 Studied the content of integrated farming and the Learning theory of Bloom, Constructivist theory, concepts and theories related to innovative creativity from various documents as guidelines for creating the learning facilitation plan

1.3 These details were used to determine the learning facilitation plan on integrated farming as shown in Table 1.

Table 1: Integrated. Agricultural Technology curriculum schedule

Integration					Situation	Work piece	Hours
Science	Technology	Engineering	Art and Agriculture	Mathematics			
Knowledge about soil, minerals, air and water for cultivation and animal domesticati on	Application of integrated farming technology	The process of creating simulated mixed farming calculation of construction costs	Integrated farming design	Computation of an area for planning integrated farming	Students were assigned to design an integrated farm of their own with unlimited capital and space	Integrated farming farm design	9

1.4. The learning facilitation plan was checked by five specialists and the IOC was found at 0.60-1.00 Then, it was improved based on suggestions of the specialists (Language used, content and time span).

1.5 The learning facilitation plan was tried out with students who not included in the sample group. After improvement, it was used with the sample group.

2. Knowledge test

The following were construction steps:

2.1 Studied documents related to measurement evaluation of the construction of integrated farming. Then, analysed objective and content based on the teaching/learning facilitation plan.

2.2 Constructed the knowledge test analysis table based on six aspects of behaviour: memory, understanding, application, analysis, assessment and creativity. After that, the knowledge test was checked by the five specialists on the basis of use of questions, questions format, options, consistency with the behaviour to be measured, linguistics accuracy and content validity. Also, the consistency between the questions and the behavioural characteristics of 30 items was considered (Item Objective Congruence Index-IOC)

2.3 Obtained scores were used to calculate the index of consistency between the questions and the behaviour, selecting only the items with an index value of 0.05 and above to represent the behaviour group with content validity. However, item with values less than 0.05 were removed or adjusted for suitability before use.

2.4 The improved knowledge test was tried out with the students who were not included in the sample group. The scores were scored on a scale of one for the correct answer and zero for the incorrect answer. After that, an analysis of difficulty and discrimination values was conducted. Items with difficulty values between 0.20-0.80 and discrimination values at 0.20 and above were selected to gain 20 questions that were based on the analysis table.

2.5 The selected knowledge test was tried out with the students who were not included in the sample group to find the reliability by using KR-20 formula, found at 0.71. After that, the selected knowledge test was used with the sample group.

3. Assessment form of creative thinking skills in integrated agricultural technology innovation

3.1 Measurement form on creative thinking skills to be used as a tool for data collection related to creative thinking skills of the students after organizing integrated STEAM learning activities. It had the following steps for construction:

3.1.1 The researcher studied academic documents and research related to creative thinking in integrated agricultural technology innovation. This aimed to determine the framework for studying the components of student characteristics having creative and innovative skills.

3.1.2 The researcher constructed innovative creative thinking skills model based on integrated learning activities of STEAM education

3.1.3 The model was checked by five specialists and then improved based on their suggestions (Language used). After that it was tried out with the sample group.

4. A form measuring the student satisfaction

It had the following construction steps:

4.1 Studied related documents, textbooks and research to prepare the form measuring the student satisfaction with the teaching model.

4.2 Constructed the 5-rating scale questionnaire by specifying the questions regarding content, activities and training media, and assessment

4.3 The student satisfaction assessment form was checked by the five specialists based on validity and IOC regarded as an acceptable quality learning facilitation plan having an index value of 0.5 and above

4.4 The student satisfaction assessment form was checked for finding the reliability value (0.74) using α-Coefficient of Cronbach (1990)

Conducting the research and analysing research data

1. The researcher collected data by herself as follows:

1.1 The sample group took the pre-test prepared by the researcher.

1.2 The researcher conducted the teaching/learning facilitation by herself for three weeks, three hours each. It was the integrated learning to promote creative thinking in technological. This comprised six steps: 1) problem identifying, 2) exploring related concepts, 3) problem solving method designing, 4) developing, 5) presenting, and 6) evaluating. After finishing the three weeks of teaching/learning facilitation, the sample took the post-test prepared by the researcher.

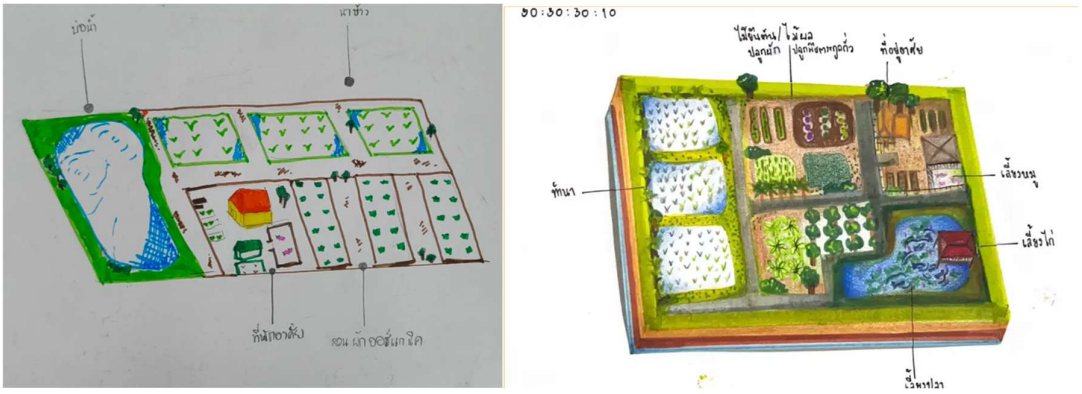


Figure 2: Teaching and learning activities during the design and development stage

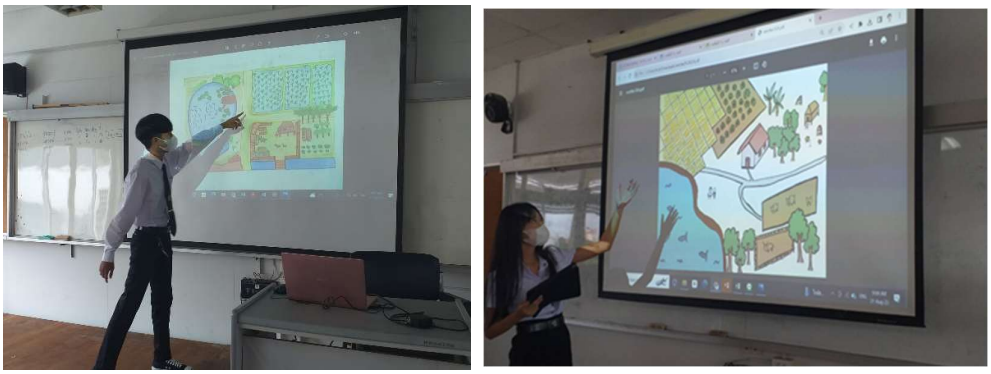


Figure 3: Instructional activities in the presentation step

2. Data analyses

The researcher analyzed various data by using the statistical package as follows:

2.1 Basic statistics - mean and standard deviation

2.2 Hypothesis testing statistics comparing academic achievement results before and after studying of the sample group by using Dependent Samples t-test.

IV. RESULTS

Results of the integrated teaching/learning facilitation to promote skills in creative thinking in innovation in integrated agricultural technology of the sample group (Nakhon Sawan Rajabhat university students) based on IEDDPE model (According to E1/E2 criteria, the first assumption was satisfied). It was found that the efficiency of the teaching model based on the concept of STEAM education combined with integrated teaching met the criteria of 80.48/87.38. Findings showed that the post-test scores were higher than the pre-test scores with a statistical significance level at .05. In other words, an average pre-test score was 9.70 (SD = 1.60) whereas that of the post-test was 15.03 (SD = 1.59) as shown in Table 2.

Table 2: Results of the comparison of scores of knowledge the pre-test and post-test

Knowledge	n	Total score	$\bar{x}$	SD	t	Sig
Before learning	21	20	9.70	1.60	15.84*	.000
After learning	21	20	15.03	1.59		

Table 3: Results of an assessment of skills in creative thinking in integrated agricultural technology innovation

Item	$\bar{x}$	SD	Description
1.Innovative creativity	3.48	0.68	Highest
2.Accuracy in work and completion of work on time	3.10	0.30	High
3.Ability to apply STEAM education knowledge	3.52	0.51	Highest
Total	**3.37**	**0.58**	**Highest**

Legend: 3.26-4.00, Highest, 2.51-3.25 High, 1.76-2.50 Low, 1.00-1.75 Lowest.

According to Table 3 as a whole, it was found that the sample group had a highest level of skills in creative thinking in integrated agricultural technology innovation ($\bar{x}$ = 3.37, SD = 0.58). Based on its detail, innovative creativity and ability to apply STEAM education knowledge were found at a highest level whereas accuracy in work and completion of work on time was found at a high level.

Table 4: Student satisfaction with the teaching model in accordance with STEAM education and integrated learning

Item	$\bar{x}$	SD	Description
Teaching/learning facilitation			
1. Students review prior knowledge and connect it to new content knowledge.	4.05	0.22	High
2. Students exchange knowledge with the lecturer and their classmates.	4.48	0.51	High
3. Students have an opportunity to ask questions when they do not understand.	4.38	0.50	High
4. Students participate in discussions and connect new knowledge to conclusions.	4.38	0.50	High
5. Students practice knowledge create innovations and present their work.	4.29	0.46	High
Total	**4.31**	**0.47**	**High**

Table 4: (Continued) Student satisfaction with the teaching model in accordance with STEAM education and integrated learning

Item	$\bar{x}$	SD	Description
Innovation in agricultural technology			
1. Students have thought process which is systematically linked and interrelated.	4.05	0.22	High
2. Students have a progressive nature.	4.24	0.44	High
3. Students transfer their ideas through speaking, writing and drawing pictures.	4.29	0.46	High
4. Students use technology for changes by using various techniques.	4.33	0.48	High
5. Students have an opportunity to check their own work and improve it.	4.33	0.48	High
6. Students have an opportunity to work and share knowledge with others.	4.48	0.51	High
Total	**4.29**	**0.45**	**High**
As a whole	**4.30**	**0.46**	**High**

Legends: 4.50-5.00 Highest, 3.50-4.49 High, 2.50-3.49 Moderate. 1.50-2.49 Low, 1.00- 1.49 Lowest.

According to Table 4, it was found that as a whole, the sample group had a high-level satisfaction with the teaching model ($\bar{x}$ = 4,30, SD = 0.46). Based on the teaching/learning facilitation, they also had a high level of satisfaction ($\bar{x}$ = 4.31, SD = 0.47). For its details, they had a high level of an opportunity to exchange knowledge with the lecturer and their classmates most ($\bar{x}$ =4.48, SD 0.51). On the basis of innovation in agricultural technology, as a whole, the sample group had a high level of it ($\bar{x}$ = 4.29, SD = 0.51). Based on its the details, they had a high level of thought process which is systematically linked and interrelated least ($\bar{x}$ = 4.05, SD = 0.22). However, they had a high level of an opportunity to work and share knowledge with other most ($\bar{x}$ = 4.48, SD = 0.51).

V. CONCLUSION AND DISCUSSION

In conclusion, the core findings of this research demonstrate that the IEDDPE teaching model, as a structured application of STEAM principles, was efficient and effective. The model successfully promoted knowledge of integrated agriculture, verifiably enhanced creative thinking skills for agricultural innovations (with students achieving a high-level mean score of 3.37), and was well-received by students, as evidenced by a high level of satisfaction ($\bar{x}$ = 4.31). This study confirms that an integrated, project-based approach can effectively develop the specific 21st-century skills required in modern agricultural technology education. However, this study's limitations primarily involve generalizability, given the small sample size (n=21) sourced from a single university via cluster sampling, and internal validity, due to the one-group pretest-posttest design which lacks a control group. The brief 9-hour intervention also makes the long-term durability of the acquired skills uncertain. Therefore, future research should replicate this study using a more robust quasi-experimental design with a control group to confirm the IEDDPE model's effectiveness. We also recommend expanding the research to

include larger, more diverse samples from multiple institutions to enhance generalizability, conducting a longitudinal study to assess the long-term retention of creative thinking skills, and broadening the assessment to include other 21st-century variables such as collaboration and critical thinking.

The integration of STEAM education (Science, Technology, Engineering, Arts and Agriculture, Mathematics) within the IEDDPE teaching model significantly enhanced students' understanding of subject content and their ability to synthesize knowledge across disciplines to create agricultural technology innovations, aligning with Yakman (2008, p. 1) assertion that STEAM education promotes creative and integrated learning by enabling learners to perceive relationships among knowledge domains and apply them to problem-solving. The six-step IEDDPE framework-problem identifying, exploring related concepts, problem solving method design, planning and developing, solution presenting, and evaluating-corresponds closely with Riley's (2012) guidelines for STEAM-based instruction, which emphasizes creative thinking through systematic problem-solving processes. The model's effectiveness was demonstrated through high student satisfaction ($\bar{x}$ = 4.31, SD = 0.47), reflecting its success in promoting experiential learning, analytical thinking, and interdisciplinary knowledge integration while fostering essential 21st-century skills such as teamwork and effective communication. Most notably, students achieved the highest level of creative thinking in agricultural technology innovations ($\bar{x}$ = 3.37, SD = 0.58), supporting Guilford's (1967) and Torrance's (1974) theories that creative thinking can be developed through appropriate pedagogical approaches. These findings are consistent with recent studies demonstrating the efficacy of integrated STEAM approaches: for instance, Jaradrawiwat (2017, p. 19) noted that Thailand's integrated learning through STEM, STEAM, and STREAM concepts develops analytical thinking and real-world knowledge application aligned with current educational policies; similarly, Chanintarapum (2020 p. 19) found that learners demonstrated significantly higher technological innovation skills after STEAM-based instruction ($p < .05$); and Malikhao et al. (2022, p. 79) reported that primary students' creative thinking improved by over 60% ($p < .05$) following STEAM education integrated with sufficiency economy principles, with self-sufficiency characteristics reaching excellence levels ($\bar{x}$ = 2.70), thereby validating the efficacy of interdisciplinary approaches in developing higher-order thinking skills and preparing learners for contemporary educational demands.

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