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THE EFFECTIVENESS OF PROJECT-BASED LEARNING MODEL WITH STEM APPROACH IN ENHANCING STUDENTS' CREATIVE THINKING SKILLS

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ABSTRACT

The crux of this study involves the formulation of a project-based learning model using the STEM approach, aimed at delineating the efficacy parameters for augmenting students' creative thinking proficiencies within the context of SMK Negeri Model Gorontalo. Employing a Research and Development framework, the study encompasses successive phases of inquiry, including preliminary investigation, blueprinting, compositional arrangement of the preliminary prototype, validation of the prototype, experimental implementation, and finalization of the product. The findings reveal that the efficacy facet of the project-based model coupled with the STEM approach falls within the range of $0.3 < g < 0.7$, thereby situating it within the intermediate classification. This inference is substantiated by the discerned n-gain percentage scores denoting the progression in creative thinking capabilities. Furthermore, outcomes stemming from student questionnaires administered during the limited scope field trials exhibit a response rate of 87%, whereas the broader public field testing elicits an 85.8% response rate. These affirmative percentages, as gleaned from student feedback, corroborate the efficaciousness of the project-based instructional model fortified by the STEM approach in fostering the augmentation of students' creative thinking proficiencies.

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INTRODUCTION

Learning tools are several means and media used by teachers and learners in carrying out the learning process, which must be prepared before the implementation of teaching (Rahayu, 2020). The learning tools developed in this research are Lesson Plans (RPP), Student Worksheets (LKPD), and Learning Outcome Tests. The curriculum currently applied in schools is the 2013 curriculum. One of the principles of the 2013 vocational high school (SMK) curriculum, according to the National Education Standards, is that in the learning process, specific principles should be included, such as practical learning, multi-entry and multi-exit, competency-based curriculum (RPL), teaching factory, and dual learning systems. The learning process is not teacher-centered but student-centered. To achieve a student-centered learning process, teachers must be able to design learning tools that include practical learning or projects, as well as incorporate skills in science, technology, and mathematics. The ultimate goal of student learning in this process is to master science and technology, specific skills in line with the competency standards of vocational high school graduates, making them ready for work, skilled, creative, technologically adept, knowledgeable, and capable of independent entrepreneurship.

Every educator is expected to be able to design effective learning tools by choosing appropriate models based on the nature of the subject matter (Prasetyo, 2015). One of the teaching models in the 2013 curriculum that fosters creativity is project-based learning (PjBL), which allows students to engage in problem-solving activities through projects. The PjBL model is well-suited for Vocational High Schools (SMKs) because it allows students to apply their knowledge in real-world business and industry contexts, develops their continuous learning interests, and enhances their critical thinking skills.

Project-based learning is a model developed around implementing projects involving students investigating real-world problems in groups (Sudrajat, 2020). Applying project-based learning is one way for teachers to involve students in their learning content. Similarly, according to Wena (2014), the Project-Based Learning model allows teachers to manage classroom learning by engaging students in project work. Project work involves complex tasks based on challenging questions and problems that lead students to design, solve problems, make decisions, conduct investigations, and work independently.

Creative thinking involves novelty, the ability to create and apply something in a new form, producing various imaginative skills that transform something new (Greenstein, 2012). Creative thinking ability is a trained habit of exploring new possibilities and generating unexpected ideas, resulting in new concepts or tangible creations that differ significantly from existing ones (Apriliani & Suyitno, 2016; Noviyana, 2017). Creative thinking is a cognitive aspect that needs attention in educational activities (Antika & Nawawi, 2017). Students often lack encouragement to develop creative thinking skills, which leads to memorization without understanding how knowledge can be applied. This is also observed in daily life, where students tend to consume knowledge without knowing how to create (Arisanti et al., 2017). Heryanti (2020) also suggests that creative thinking skills can be enhanced using the STEM approach (science, technology, engineering, mathematics).

STEM education is considered a significant approach for creating meaningful changes in the 21st century. It's a strategy formulated by scientists, technologists, engineers, and mathematicians to blend strengths and create stronger and more impactful learning experiences (Kairiyah, 2019). STEM education in vocational fields aims to prepare students to compete and be ready for their specialized domains (Simarmata, 2020). STEM-based learning is particularly suitable for Vocational High Schools (SMKs), as it combines theoretical knowledge with practical learning experiences, enhancing skills in science, technology operation, problem-solving techniques, and mathematics. This prepares students for challenges in the business and industrial worlds.

To improve the learning process, especially in the Agribusiness of Food Crops and Horticulture field at the Model Gorontalo State Vocational School, vocational subject teachers should design appropriate learning plans and choose active and student-centered learning media. Effective implementation of this approach in vocational schools is expected to yield positive outcomes, contributing to the achievement of national vocational education goals. Active learning in vocational subjects motivates students and creates enjoyable learning experiences, thereby enhancing creative thinking skills and learning outcomes. In the context of the study, the topic of fertilizer for vegetable crops lacks project-based learning with the STEM approach, resulting in passive student engagement and a lack of direct experience. Therefore, the research and development aim to create project-based learning tools with a STEM approach to enhance creative thinking skills. This

research aims to assess the effectiveness of the project-based learning model with a STEM approach in improving creative thinking skills.

METHOD

This research and development utilize the Borg and Gall R&D model, which is simplified into 6 stages: preliminary study, planning, initial product development, product validation, product testing, and final product. The research is conducted at the Model Gorontalo State Vocational School, specifically focusing on the Agribusiness of Food Crops and Horticulture competency field. The limited-scale pilot involves 10 respondents, while the large-scale test involves 27 students in Grade X.

This study falls under the development research type. The researcher is developing learning tools, including Lesson Plans (RPP), Student Worksheets (LKPD), and testing instruments for the topic of plant fertilization. The aim is to create a valid, practical, and effective project-based learning (PJBL) model that supports creative thinking skills.

The study takes place at the Model Gorontalo State Vocational School in Bone Bolango Regency, Gorontalo Province. The research is conducted from March to June 2022. The research targets Grade X students in the Agribusiness of Food Crops and Horticulture competency field at the Model Gorontalo State Vocational School. The limited-scale test is carried out with ATPH 1 class, consisting of 8 students, while the large-scale test involves ATPH 2 class with 21 students.

The research employs a development method, specifically the research and development (R&D) approach. The products developed are learning tools, including Lesson Plans, Student Worksheets, and testing instruments. These tools are meant to enhance students' understanding of the basics of plant cultivation, specifically in the context of plant fertilization.

The product to be developed is a learning tool using the PJBL model with a STEM approach to enhance creative thinking and science process skills for Grade X ATPH students. The research and development process follows Borg and Gall's steps, which include (1) research and information collection, (2) planning, (3) developing the preliminary form of the product, (4) preliminary field testing, (5) main product revision based on field testing results, (6) main field testing, (7) operational product revisions based on field test feedback, (8) operational field testing, (9) final product revision, and (10) reporting the research.

Sukmadinata (2005) simplifies the Borg and Gall model into three steps: preliminary study, model development, and model testing (validation). The preliminary study involves literature review and field surveys. The development phase includes creating a draft, limited testing, and large-scale testing. The third phase is an experiment to validate the developed product.

The development stages in this research adhere to Borg and Gall's suggestions and are modified into 7 steps: (1) preliminary study, which includes curriculum analysis, availability of learning tools, and school infrastructure; (2) planning the product specifications and content structure of learning tools; (3) designing the learning tool product, which includes Lesson Plans, cognitive assessment sheets, psychomotor assessment sheets, affective assessment sheets, Student Worksheets, and testing instruments; (4) product validation through expert, teacher, and peer validation; (5) revising the product based on expert feedback (revision I); (6) limited testing involving 8 students, followed by an evaluation and large-scale testing with 21 students (revision II); (7) revising the product based on large-scale testing feedback (revision III). Data collected include the effectiveness of the product, measured through learning outcome test instruments.

RESULTS AND DISCUSSION

Limited Field Test

Students' Creative Thinking Skills

The assessment of students' creative thinking ability test results was conducted in both the limited field trial and the extensive field trial, each carried out during the first to third sessions. Similar to other studies, the analysis of students' creative thinking tests included pretests and post-tests for each session.

Based on the analysis of creative thinking skills test results for students in the limited field trial class, which covered sessions 1 to 3, a total of 10 students participated. In the pretest results, students' creative thinking skills aligned with the indicators of creative thinking: fluency at 47.4%, flexibility at 32.5%, originality at 42.5%, and elaboration at 30%. In contrast, in the post-test, students' creative thinking skills according to the indicators were fluency at 80%, flexibility at 65%, originality at 70%, and elaboration at 72.5%. The following graph illustrates the assessment results of the creative thinking skills learning outcome test in the limited field trial.

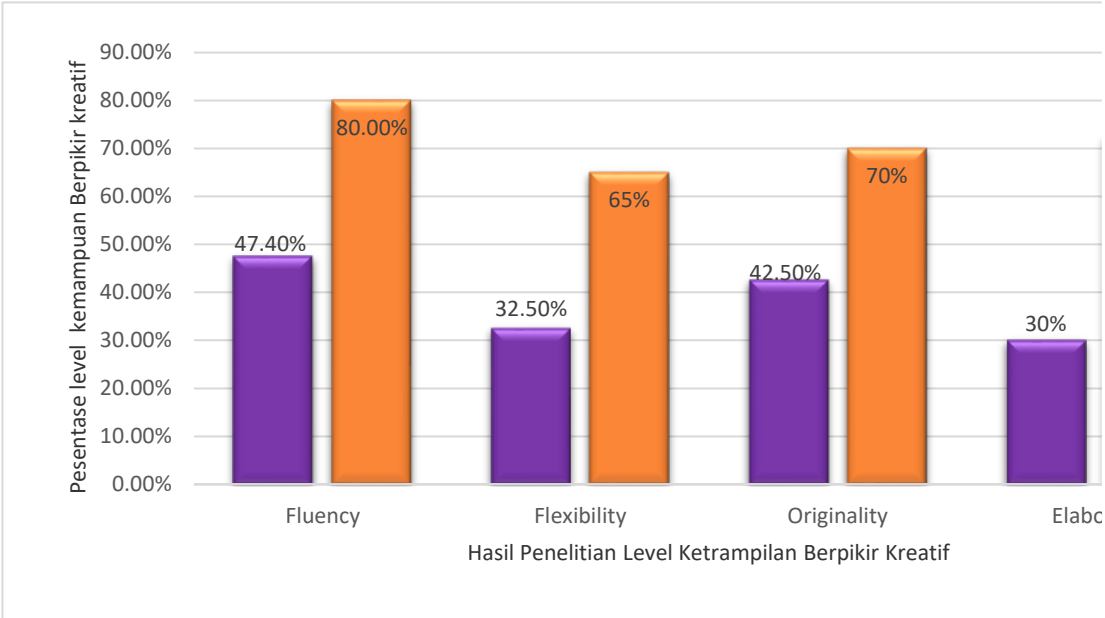

Figure 1. Graph of the results of the Limited Scale Test Creative Thinking skills assessment

Table 1. N-Gain Analysis of Creative Thinking Skills Limited Scale Test

Indicators of creative thinking	**Score**			**Category**
	Pre-test	***Post-test***	**N-*gain***	
Fluency	47,4	80	0,6	Moderate
Flexibility	32,5	65	0,5	Moderate
Originality	42,5	70	0,4	Moderate
Elaboration	30	72,5	0,7	Moderate

Based on the data in Figure 1, the test of creative thinking ability is highly significant. This is supported by the statement from Treffinger et al. as cited in Irwandi (2020), which asserts that the creative thinking test generates numerous ideas (fluency), diverse new ideas (flexibility), uncommon new ideas (originality), and enriches interesting and complex ideas (elaboration). This significant increase is attributed to factors such as the students' enthusiasm in participating in the learning process and the conducive classroom environment that supports active learning. As a result, the scores in the creative thinking test have improved.

Student Response

A student response questionnaire was administered to gather data on students' perceptions during the learning process utilizing the project-based learning model with a STEM approach. The responses were categorized into "YES/NO" answers on the questionnaire, and a total of 10 respondents participated in the limited-scale pilot. The calculated criterion score for student responses was 97, with a Student Response Percentage of 87% in the limited-scale pilot. This score determines the category of student response assessment, placing the overall criterion score for student response within the range of 86-100%, which falls under the "Very Good" category.

N-Gain Analysis Results

The analysis of pre-test and post-test results from students' assessments was used to calculate the N-Gain values, indicating the improvement in students' creative thinking skills. The N-Gain analysis results are presented in Table 1. The calculated N-Gain values for the fluency indicator were 0.6, for flexibility 0.5, for originality 0.4, and for elaboration 0.7. These values fall within the "moderate" category, indicating that the project-based learning model with a STEM approach is moderately effective in enhancing students' creative thinking skills. This finding is in line with previous research by Riyanti (2020), which demonstrated that the integration of web-based

STEM-oriented PjBL learning tools can moderately enhance students' creative thinking abilities.

Large-Scale Field Test

Thinking Skills Assessment

The assessment of student learning outcomes in the large-scale field test was conducted in Grade X at the Model Gorontalo State Vocational School. A total of 27 students participated in this field test, making their creative thinking ability test results the primary data for the researcher. In the pretest results, students' creative thinking skills were as follows: fluency skills at 43%, flexibility skills at 38%, originality skills at 42.6%, and elaboration skills at 30%. Meanwhile, in the post-test results, students' creative thinking skills were as follows: fluency skills at 85%, flexibility skills at 62%, originality skills at 77%, and elaboration skills at 67.4%. The following graph illustrates the assessment of creative thinking skills in the large-scale field test.

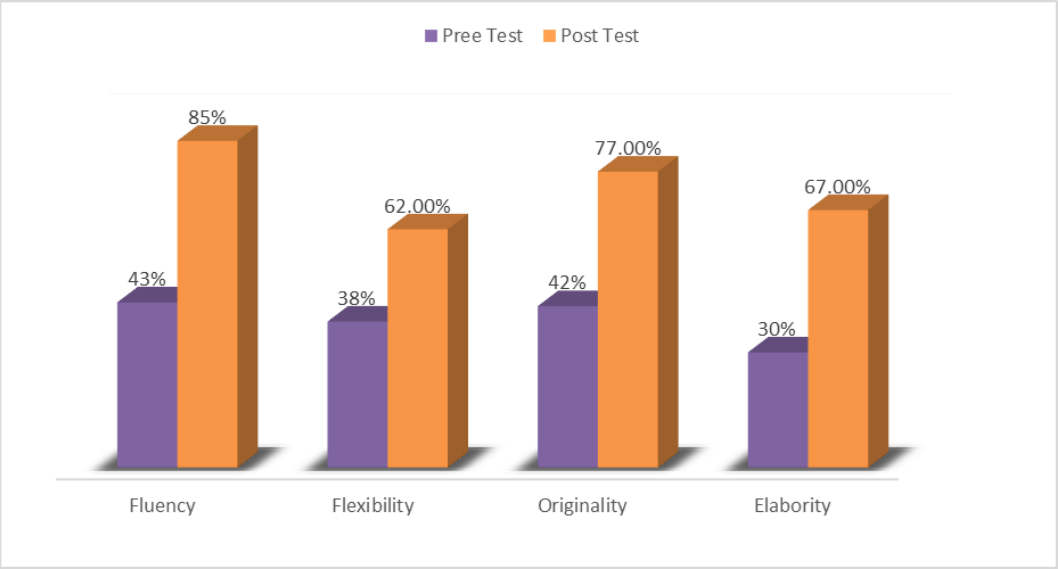

Figure 2. Graph of the assessment of Creative Thinking skills on a Wide Scale Test

Table 2. N –Gain Analysis of Creative Thinking Skills Test Wide Scale Test

Indicators of creative thinking	Score			Category
	Pre-test	*Post-test*	N-*gain*	
Fluency	43	85	0,6	Moderate
Flexibility	38	62	0,4	Moderate
Originality	42	77	0,5	Moderate
Elaboration	30	67	0,6	Moderate

The research data above indicates that the Indicator of fluent thinking (fluency) has the highest percentage, which is 85%. These results show that students are capable of generating multiple answer ideas or thinking of more than one solution to solve a problem. This is in line with the opinion of Febrianti et al. (2016) that students who possess fluent thinking skills are those who can propose several questions, adeptly convey concepts or ideas, and exhibit quicker thinking abilities compared to the average student.

The Indicator of flexible thinking has a low percentage, specifically 62%. In this indicator, students still struggle to provide diverse solutions (from various angles). This aligns with the perspective of Fajriah & Asiskawati (2015) that flexibility in creative thinking is linked to the ability of students to generate numerous ideas and those ideas must exhibit variation. This is consistent with the viewpoint of Firdaus et al. (2018) that the low attainment in flexibility is due to the students' weakness in perceiving or considering something from different perspectives. This issue deserves attention because students' lack of achievement in this competency could lead to a thinking pattern where they tend to only focus on one side when approaching a subject or problem.

The Indicator of original thinking has a percentage of 77%. In this indicator, students are able to produce answers using their own language. This is in accordance with the perspective of Samura (2019) that originality is the skill of students to solve problems in their own way, or in other words, in a manner that is not typically thought of by others.

The skill of elaboration ability has a low percentage, 62%, following flexibility. This indicates that students encounter some difficulties in explaining an idea or elaborating on the details of an experiment, such as the creation of a liquid organic fertilizer project. This skill can be identified through the way students provide detailed answers and expand on ideas (Febrianti et al., 2016).

The achievement of each creative thinking indicator is fairly good. The indices of fluent thinking and original thinking fall under the category of "good." The indicators of flexible thinking and elaboration ability are rated as "fairly good." The limitations in the abilities of flexible thinking and elaboration, which are categorized as "fairly good," are attributed to some students struggling to generate varied answers or solutions, as well as to develop ideas.

Student Response

A student response questionnaire was administered with the aim of obtaining data on student responses during their participation in the learning process using the project-based learning model with a STEM approach. The student response questionnaire consisted of 10 items, which were then completed by the students based on their respective feedback.

The data on student responses during the learning process were indicated by the number of students who answered YES/NO to statements on the response questionnaire sheet, with a total of 24 respondents in the large-scale trial. The calculation of student response criteria resulted in a total score of in the large-scale trial, with a Student Response Percentage of 85.8. This value determined the assessment category for the student response questionnaire, placing the overall student response criteria score for the learning process within the range of 70 to 85, which falls under the "good" category.

The obtained results of student responses demonstrated a positive attitude towards the learning process and the developed teaching materials. The students' responses were attributed to the fact that the learning process engaged them not only through lectures but also through involvement in project-based learning activities. Within these activities, students were active participants, starting from the project planning phase, selecting the materials for creating liquid organic fertilizer, scheduling the project, carrying out the project, to communicating the project results.

N-Gain Analysis

Based on the results of the students' pre-test and post-test assessments, the gain values were calculated to observe the improvement in the students' Creative Thinking Skills. The outcomes of the N-Gain analysis are presented in Table 2. The N-Gain calculations resulted in values of 0.6 for the fluency indicator, 0.4 for flexibility, 0.5 for originality, and 0.6 for elaboration. All four indicators of creative thinking skills fall into the moderate category, indicating that the instructional approach using the project-based learning model with a STEM approach is sufficiently effective in enhancing the creative thinking skills of the students.

CONCLUSION

The research results indicate the quality of the products generated based on the effectiveness aspects of the project-based learning model with a STEM approach, as demonstrated by the percentage of N-Gain values showing an average increase in creative thinking skills falling within the range of $0.3 < g < 0.7$, which falls under the moderate category. Meanwhile, the participants' responses through the questionnaire yielded an average score of 87% for the limited trial and an improved average score of 85.8% for the extensive trial. This suggests that the students have shown a positive response to the learning process. Based on the research findings, it can be concluded that the development of the instructional approach using the project-based learning model with a STEM approach has been effective in enhancing the creative thinking skills of the students.

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