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ORIGINAL RESEARCH

Application of STEM-Integrated Problem Based Learning Model to Improve Learners' Creativity

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Abstract

The purpose of this study is to describe how the implementation of learning with the STEM-integrated problem-based learning model can increase student creativity. This study used a quantitative method with a pre-experimental design in the form of a one group pre-test post-test design which was carried out in one of the high schools in Sumedang Regency. The sample in this study were 43 students in class X MIPA at the school. The sampling technique used is purposive sampling. The data collection instrument used to measure student creativity is the Cognitive, Processes Associated with Creativity test (CPAC) which consists of 8 statements related to act and flow aspects given during the pre-test and post-test, and student creativity observation sheets to observe the emergence of student creativity during learning. which includes aspects of flexibility, fluency, originality, elaboration, and clarification. In this study, learning was carried out using a problem-based learning model by integrating STEM elements in momentum and impulse topic. The data analysis technique to measure the improvement in students' creativity involved descriptive statistics, N-Gain calculations, and categorization of the assessment results. The research results show that the improvement in students' creativity, based on the N-Gain analysis of pre-test and post-test scores, is 0.433, which falls into the moderate category for the aspects of act and flow. Meanwhile, for the aspects of flexibility, fluency, originality, elaboration, and clarification, the results fall into the good category with a percentage of 77.56%. So based on the analysis of the findings in the research, the application of the STEM- integrated problem-based learning model can increase students' creativity.

Keywords: Problem Based Learning · STEM · Creativity · Momentum and Impulse

INTRODUCTION

The development of education in the 21st century has undergone various changes along with technological advances which have led to increased expectations and new demands in order to adapt to this time. Education is one of the main components that must be improved in the face of progress in the 21st century, where learning is not only designed to understand concepts but also how these concepts are used in everyday life for social survival (Zayyinah et al., 2022). In the definition of the framework created by P21, in 2009 the Framework for 21st Century Learning was developed to describe the skills, knowledge and expertise that learners must master to succeed in work and life, which is a combination of content knowledge, specialised

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skills, expertise and literacy. In the area of learning and innovation skills, it focuses on creativity, critical thinking, communication and collaboration (for 21st Century Learning, 2015).

According to the Kemendikbud (2017), the four competencies that students must have in the 21st century are 4C, including Critical Thinking and Problem Solving, Creativity, Communication Skills, and Ability to work Collaboratively (Kemendikbud, 2017). Creativity is one of the 21st century skills that learners need in facing technological advances and preparing for their future careers. Research conducted by Hanif, Wijaya, and Winarno (2019), based on educator interviews, many still only measure cognitive aspects. From this, there are indications that students have lacking skills, especially in terms of creativity (Hanif et al., 2019). Creativity can be trained by getting students used to thinking creatively, these skills will make students tend to be able to find solutions to problems so that they are accustomed to developing their own reasoning in understanding the material presented by educators (Adawiyah et al., 2019).

Education in Indonesia is currently implementing 21st century learning nationally at the primary and secondary school levels, and a programme to strengthen character education in schools which is expected to foster the character of students to be able to think critically, creatively, communicate, and collaborate. Teacher innovation, creativity, and sensitivity are needed in learner-centred learning activities because 21st century skills are not the ability to memorise but the ability to apply concepts and solve various problems in real life (Apriliana et al., 2018). Physics learning is not only seen as a product, but also must be reviewed how the process is, so in the learning process it is necessary to select appropriate and appropriate strategies, methods, and models to increase the effectiveness of learning. The application of appropriate learning strategies and approaches will help students train and develop science process skills so that they are able to obtain information, formulate problems, plan experiments, and solve problems (Adawiyah et al., 2019).

The STEM approach in education is an integration of science, technology, engineering and mathematics learning, which is suggested to help the success of 21st century skills. STEM is designed to develop various 21st century skills that can be used in all areas of daily life, such as reasoning, problem solving, critical thinking, creative and investigative skills, independent learning, technological literacy, teamwork and collaboration, and various other skills. Through well-implemented STEM learning and proper design, students will be better able to solve problems in the real world (Pratiwi et al., 2021; Zubaidah, 2019). Problem-based learning (PBL) is a learning that is based on a contextual problem so that it can encourage students to learn to solve problems and students' creative thinking skills can be developed (Vistara et al., 2022). In its implementation, STEM can be integrated with Project Based Learning, Problem Based Learning, Discovery Based Learning and Inquiry Based Learning (Dewi, 2017).

In this study, a STEM-integrated problem-based learning model was implemented on momentum and impulse material. The concept of momentum and impulse is close to the lives of students and can be applied to technological products such as helmet construction, crumple zone in cars, airbag construction, and crack of the bat (Purwaningsih et al., 2020). Based on these characteristics, the concepts of momentum and impulse are commonly used in engineering and technology so that constructivist learning such as STEM-integrated PBL can encourage students' activities and skills, learn to use their own ideas and initiatives, so that

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students are motivated to be more optimal in learning. Learners are also encouraged to have inventiveness or creativity and the ability to utilise and master technology (Ningsih, 2020).

Problem-based learning can increase students' learning creativity, the process of problem solving in learning will provoke the growth of learning creativity. The results of research conducted by Manobe (2018) stated that problem-based learning can increase students' learning creativity, the process of problem solving in learning will provoke the growth of learning creativity. According to Farwati (2017) it is possible to collaborate STEM education in problem-based learning, learning outcomes that intersect with environmental literacy and creativity can be realised through the implementation of PBL-STEM (Farwati et al., 2018; Manobe & Wardani, 2018).

Based on the above literature that the STEM-integrated problem-based learning model is able to increase students' creativity in learning, the researcher feels the need to find out the increase in students' creativity in solving problems through a problem-based learning model by integrating STEM on momentum and impulse material.

METHOD

This study uses a quantitative method with the type of pre-experimental design, in the form of a one group pretest-posttest design (Sugiyono, 2019), which is given a pretest before treatment and a posttest after treatment so that the treatment results can be known more accurately because they can compare the two results obtained, and are supported by observations of the emergence of student creativity during learning. The STEM-integrated problem-based learning model with the topic of momentum and impulse was applied. The sample in this study were X MIPA students in one of the high schools in Sumedang Regency as many as 43 students. The sampling technique used was purposive sampling. This technique is a sampling technique with certain considerations, the consideration in question is that the school does not group its classes based on ability levels (no superior class). In other words, the distribution of students in this school is heterogeneous so that it can represent students from high, medium, and low ability levels.

The instruments in this study in the form of CPAC (Cognitive, Processes Associated with Creativity) tests were used as pretests and posttests in the form of 8 statements with answer choices in the form of a 4-point Likert scale, and student creativity observation sheets filled in based on the results of student observations. The CPAC test data analysis technique used the Gain normality test, and the creativity observation results were analysed using the average percentage.

RESULTS AND DISCUSSION

Improving Students' Creativity

Analysis of CPAC Test Data (Cognitive Processes Associated with Creativity)

This data represents students' responses related to creativity, expressed through the degree of agreement with statements based on their experiences before (pretest) and after (posttest) the treatment. The test consists of 8 statements grouped into two factors: 'act', referring to conscious and active behavior, and 'flow', referring to subconscious, experience-based processes (Conradty & Bogner, 2018). A 4-point Likert scale was used, ranging from 'never' (1) to 'often'

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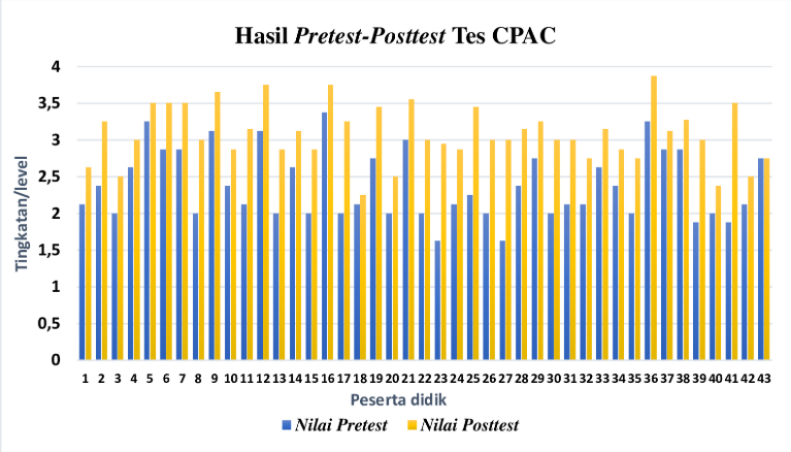
(4). The summary of CPAC test scores, used to measure the enhancement of students' creativity, is presented in the graph in Figure 1.



Gambar 1. Summary of CPAC test scores

Figure 1 shows that nearly all students obtained higher posttest scores compared to their pretest scores. The average pretest score was 2.381 on a 4-point scale, indicating that the frequency or agreement with the statements in the test ranged from 'occasionally' to 'often'. The average posttest score was 3.082, which suggests that students' responses reflected a frequency ranging from 'often' to 'very often' based on the CPAC test statements.

Based on the average pretest and posttest scores, a gain score was calculated to determine the extent of improvement in students' creativity in the aspects of *act* and *flow*. The results of the gain score calculation are presented in Table 1.

Table 1. Summary of N-Gain Calculation Results

Average Pretest Score	Average Posttest Score	N-Gain Score	Criteria
2.381	3.082	0.433	Moderate

From Table 1, it can be seen that the normalized gain score for students' creativity is 0.433, which, according to Richard R. Hake, falls within the moderate category. This score indicates an improvement in students' creativity after the implementation of problem-based learning integrated with STEM.

Analysis of Student Creativity Observation Data

The data obtained from the observation of students' creativity during the PBL model integrated with STEM learning were calculated and expressed as percentages for each student, then further percentage calculations were made for each creativity aspect and overall. These data are presented in Table 2.

Tabel 2. Summary of the Percentage of Creativity Aspects Based on Observation Results

No.	Creativity Aspect	Percentage (%)	Criteria
1	Flexibility (ability to adapt in groups)	89.53	Very Good
2	Fluency (ability to generate varied ideas or concepts)	72.67	Good

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No.	Creativity Aspect	Percentage (%)	Criteria
3	Originality (ability to generate new ideas or concepts)	71.52	Good
4	Elaboration (ability to respond to and answer questions)	73.26	Good
5	Clarification (ability to present discussion results in front of the class)	80.81	Good
	Average	77.56	Good

Based on the percentage recap results in Table 4.2 for each creativity aspect, students were able to demonstrate creativity in learning well, especially in the flexibility aspect, which reached a score of 89.53% with an excellent rating. This indicates that most students were highly adaptable during the learning process, particularly during group discussions to solve problems, which aligns with the *flow* aspect, specifically statements 6, 7, and 8 in the CPAC test, which express comfort and enjoyment while solving problems or completing tasks, making the work easier when it is enjoyable, and losing track of time while working hard. In the fluency aspect, the score was 72.67%, and in originality, it was 71.52%, both with a good rating. This means that students were able to generate new and varied ideas, which corresponds with the *act* aspect in the CPAC test, specifically statements 1 and 2, which indicate the ability to combine different concepts to generate new ideas and use previously applied solutions in new ways to solve problems. In the elaboration aspect, the score was 73.26%, with a good rating, meaning that students were able to respond to and address questions or problems well, which corresponds with the *act* aspect supporting statements 3, 4, and 5 in the CPAC test. These statements indicate that students are able to relate problems to relevant situations, view problems from different perspectives, and then imagine possible solutions to solve the problems accurately and make them useful. In the clarification aspect, the score was 80.81%, with a good rating, meaning that students were able to present and communicate the results of their discussions effectively in front of the class.

On average, the overall creativity scores of students across the five aspects flexibility, fluency, originality, elaboration, and clarification was 77.56%, with a good rating. Based on the N-Gain data analysis, which showed a score of 0.433, indicating a moderate improvement in students' creativity, supported by the creativity percentage of 77.56% based on observation results with a good rating, it can be concluded that learning with the PBL model integrated with STEM in the topic of momentum and impulse can enhance students' creativity. This is in line with the research conducted by Vistara (Vistara et al., 2022), which states that the implementation of the problem-based learning model integrated with STEM can improve students' creative thinking skills, and the research conducted by (Ernawati et al., 2020) also reported that students who engaged in problem-based learning showed higher creativity compared to students who participated in traditional learning.

CONCLUSION

Based on the research results and discussion, it can be concluded that the enhancement of students' creativity after the implementation of the problem-based learning model integrated with STEM in physics learning on the topic of momentum and impulse, based on the N-gain results, is 0.433, which falls under the moderate category in the aspects of *act* and *flow*.

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Additionally, in the aspects of flexibility, fluency, originality, elaboration, and clarification, the creativity scores are rated as good, with an average percentage of 77.56%. The implementation of the problem-based learning model integrated with STEM can have a positive impact on improving students' creativity, particularly in physics education.

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