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Dynamic Fluid Module: Problem-Based Learning Combined with STEM to Increase Students' Scientific Creativity

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Abstrak: Scientific creativity is one of the main competencies in 21st century life, but this competency is not practiced in schools. This study aims to describe the effectiveness of dynamic fluid module using STEM-PBL to improve students' scientific creativity. This module contains lesson plans, module content, materials and scientific creativity tests. This research includes research and development using an adaptation of the ADDIE model. The research trial used a one group pretest and posttest design on 21 students of class XI IPA 1 SMA Negeri 1 Takisung. Data were obtained from student learning outcomes tests, with module effectiveness of 0.41 in the moderate category. Thus, the dynamic fluid module using STEM-PBL developed is effective for increasing students' scientific creativity.

Keywords: Fluid dynamics; Problem-based learning; Scientific creativity; STEM

Introduction

In the 21st century, science and technology are developing quite rapidly and influencing all areas of life, especially in the field of education. This development creates new challenges for the world of education, especially in Indonesia. One effort to face these challenges is by providing certain skills to students. One of the learning activities that requires these skills is physics. Physics is a science that studies matter or substances which includes physical properties, composition, actions and energy produced (Mulyadi, 2016). Physics is also a branch of science that studies objects that exist in nature physically and written mathematically so that they can be understood and utilized by humans which is useful for the welfare of humanity (Hudha et al., 2017). Apart from that, physics is also the science of the universe for practicing, thinking and reasoning through one's reasoning abilities (Erviani et al., 2016). Izaak (2010) states that physics is not only limited to learning facts, concepts, principles and laws, but also about how to obtain information, apply technology, work scientifically and the ability to think creatively (Pistanty et al., 2015). In learning physics, creative thinking skills can help students to build new knowledge. So that in facing the challenges of the 21st century, an educator must prepare students to become investigators, problem solvers and able to think critically and creatively (Trianggono, 2017).

The ability to think creatively is one of the important demands in the world of education, because this ability provides new ideas by thinking and realizing imagination and provides opportunities for students according to fluency, flexibility, originality and detailing/elaboration (Wahyuni et al., 2018). Creativity in science learning is called scientific creativity (Inayah et al., 2020). Scientific creativity is the ability to produce a particular product that is original and has social value or personal value, and is designed with a specific purpose in mind using existing information (Setyadin et al., 2017).

From the results of observations and interviews by Ismayanti et al. (2020) obtained information that there are still many students who experience difficulties in working on physics problems that measure indicators of

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creative thinking skills. This is strengthened by the results of research by Fardah (2012) which states that the creative thinking patterns of students with high criteria are 20%, medium are 33.33% and low are 46.67%. This statement states that students' scientific creativity is currently still relatively low. This is due to the lack of support for learning activities that lead to creative thinking abilities. Because the learning methods used are limited to lectures and assignments. So the devices created only focus on cognitive aspects and pay less attention to other aspects. Researcher conducted an interview with one of the physics subject educators at SMA Negeri 1 Takisung on December 15 2022. Based on the results of the interview, information was obtained that students in class XI IPA at SMAN 1 Takisung still had difficulty understanding physics concepts properly, this is because students' numeracy skills in solving problems and solving physics problems are still lacking. As a result of the lack of these problems, students' creative thinking abilities become low. So far, educators have taught using a direct learning model and sometimes carry out experiments so that students receive more information from the teacher. The learning tools used in learning are still based on textbooks and there are no learning tools that are specifically designed to increase scientific creativity. Thus, there needs to be innovation in the learning process that is able to increase students' scientific creativity.

One effort to overcome the above problems is to develop teaching modules that are used to increase students' scientific creativity. The module aims to facilitate effective, efficient learning objectives that can be owned by both educators and students (Ministry of National Education, 2008). To improve the quality of learning, innovation that can be implemented is developing modules based on Problem-Based Learning combined with STEM (STEM-PBL). PBL is a student-centered method (Student Centered) and is also a learning model with problem solving patterns carried out by students collaboratively (Lestari, 2012). This learning encourages high-level thinking competencies and develops students' creative thinking competencies (Hagi et al., 2021), so that students' creative thinking skills will develop in the learning process (Lestari, 2012). The application of PBL in the learning process helps students to mature their thinking abilities, so that they are able to train students' creative abilities. This is stated based on the research results of Septian et al. (2017) stating that the increase in creative thinking abilities of students who learn using the PBL learning model is better than students who study using conventional learning models.

The application of the PBL model can be integrated with the STEM (Science, Technology, Engineering and Mathematics) approach to support the achievement of learning goals. The STEM approach is a learning consisting of science, technology, engineering and mathematics which is used to develop students' scientific creativity through the process of solving problems in everyday life (Khariyah, 2019). The National Research Center states that with STEM education, students are also able to develop cognitive abilities in accordance with 21st century abilities, namely adaptability, complex communication, non-routine problem solving, self-management and systems thinking (Mu'Minah et al., 2019). STEM also makes the learning process relevant and meaningful, so that students' attitudes and thinking skills can improve (Stohlmann, 2018). The STEM-PBL approach is a learning model carried out by students collaboratively to improve creative thinking. So the STEM-PBL approach will be centered on students who not only solve mathematical problems, but are also linked to STEM aspects.

The success of STEM-PBL based modules in physics learning can be proven by several studies, including research by Fathurohman et al. (2021) states that STEM-PBL based modules on Newton's Laws of Motion material are suitable for use as teaching materials in high school. Other research by Dewi et al. (2020) states that students' creative thinking skills through STEM-PBL have good implications and support the process of learning activities that are effective and enjoyable for students. Octafianellis et al. (2021) stated that the application of STEM integrated PBL helps students gain experience from studying situations, solving complex problems, and gaining in-depth understanding to improve HOTS, especially creative thinking skills. Based on the description above, it is necessary to carry out research aimed at producing effective learning modules using STEM-PBL to increase students' creativity in dynamic fluid material.

Method

The method used in this research is research and development (R&D). The trial design used a single group Pretest-Posttest design (One Group Pretest-Posttest Design). This means that before the treatment is carried out, the sample is given an initial test (pretest) first then at the end of the treatment, the sample is given a final test (posttest) (Kristiani et al., 2017). The following is the scheme of one group pretest-posttest design (Sugiyono, 2019).

Table 1. One Group Pretest-Posttest Design

Pretest	Treatment	Posttest
Q1	X	Q2

Note: Q_1 = pretest score (before treatment), X = learning process, Q_2 = posttest score (after treatment).

The research trial subjects were 21 students in class XI IPA 1 at SMA Negeri 1 Takisung for the 2022/2023 academic year. The object of the research is the effectiveness of developing dynamic fluid modules using STEM-PBL to increase students' scientific creativity. The research was conducted from January to June 2023 located at SMA Negeri 1 Takisung, Tanah Laut, South Kalimantan, Indonesia.

The effectiveness of the dynamic fluid module using STEM-PBL is measured based on the results of student learning tests (pretest-posttest). The results of these two tests were then analyzed using the normalized gain gain (N-Gain) test to determine the effectiveness of students' scientific creativity.

$$\langle g \rangle = \frac{\langle S_f \rangle - \langle S_i \rangle}{SM - \langle S_i \rangle} \quad (1)$$

Note: $\langle S_f \rangle$ = Pretest score, $\langle S_i \rangle$ = Posttest score, SM = Maximum score.

The results of the N-Gain calculation of students' scientific creativity are entered in the N-Gain ⟨g⟩ criteria with the criteria listed in Table 2.

Table 2. N-Gain Criterion of Scientific Creativity (Hake, 1998)

N-gain	Criteria
$\langle g \rangle > 0.70$	High
$0.30 \leq \langle g \rangle \leq 0.70$	Medium
$\langle g \rangle < 0.30$	Low

Result and Discussion

The module developed in this research is to increase students' Scientific Creativity which is linked to dynamic fluid material based on the 2013 Curriculum. The physics module developed as an integrated STEM-PBL guarantees that learning activities are carried out smoothly during face-to-face learning. Face-to-face activities are learning activities in the form of an interaction process between students, learning materials, educators and the environment. So face-to-face learning is designed to support students' face-to-face. learning process by taking into account external events that play a direct role in students which can be known or predicted (Tandi et al., 2021). The module developed consists of a cover, foreword, table of contents, introduction, lesson plan, concept map, instructions for using the module, sub-chapter titles, material description, let's try!, summary, STEM activities, comprehension test, self-assessment, glossary, list library, answer key, glossary. The following product being developed is shown in Figure 1.

Figure 1. Initial appearance of the cover and subchapters

At the end of each meeting there is a STEM activity which aims to train students' scientific creativity. Apart from that, there are also comprehension tests and self-assessments that students must complete independently. It is hoped that the questions given can train students' scientific creativity. STEM activities, understanding tests and self-assessments are seen in figure 2.

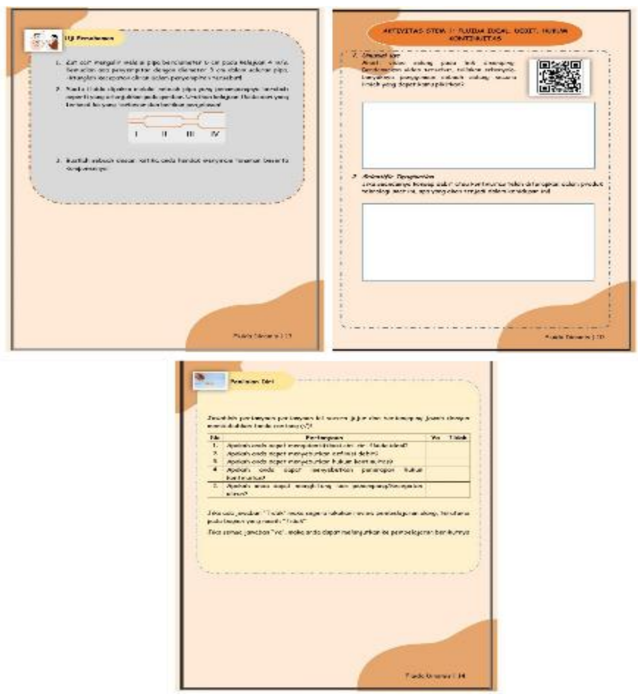
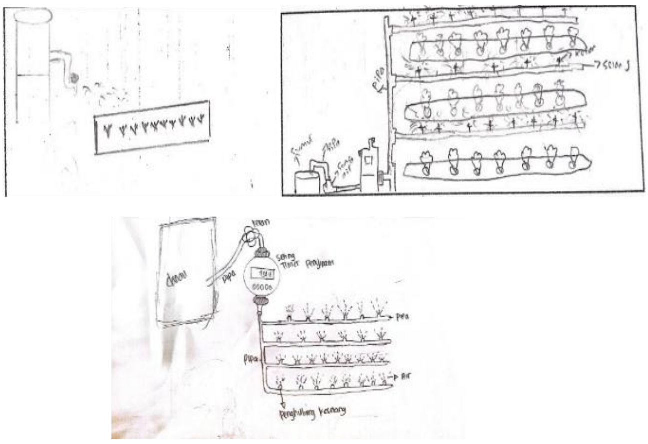
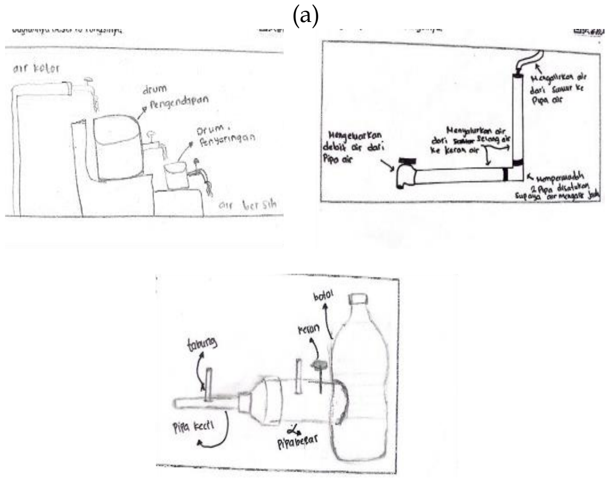


Figure 2. STEM activities, test understanding and self-assessment

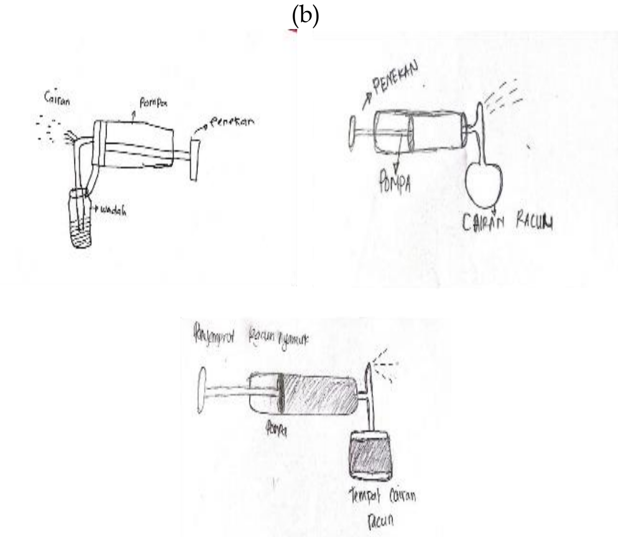
As for the results of the STEM activities from the three meetings, students were able to design a creative product. Which can be seen in figure 3.



(a)



(b)



(c)

Figure 3. (a) Plant watering design; (b) Water distribution design; (c) Mosquito sprayer design

The advantages of developing modules with a problem-based learning model combined with STEM are that they are developed based on the 2013 curriculum which emphasizes the responsibility to maximize students' scientific creativity which is optimized through creative and imaginative ideas, so that each student can develop their thinking abilities to increase product usefulness technical and designing creative products. Another advantage of the module developed is that the learning module uses problem-based learning combined with STEM which combines the four main fields of science, technology, engineering and mathematics.

The effectiveness of the dynamic fluid module using STEM-PBL is measured based on the results of students' scientific creativity obtained through pretest and posttest using the developed module. The test given is an essay test consisting of 5 questions. Scientific creativity is then analyzed using the normalized gain (n-gain) equation. The calculation results can be seen in Table 3.

Based on the test results, it shows that the scientific creativity scores of students are still low, as seen in Table 3. In the pretest, there were 6 students who still had the criteria of not being good, 8 people were fairly, 5 people were fairly good and there was only 1 student who had good criteria. From the statement above it can be concluded that the pretest produced has low criteria. When the pretest was given, there were some students who were only able to write down the use of an object, know it and ask questions, there were also students who only half completed the answers to the questions because the students still had difficulty using physics equations and there were some students who did not understand the contents of the questions related to indicators of scientific creativity such as improving technical products and students' ability to imagine scientifically is also lacking. After the pretest was carried out, the next meeting was given the dynamic fluid module that had been developed and learning was carried out in three meetings with the same treatment between students.

In Table 3, it can be seen that the posttest scores obtained by students after learning using the module gave good average results. However, there are still some students who have the criteria below which are fairly good. This is because there are indicators that are still low. Cahyono (2019) stated that there are two factors that cause learning difficulties, namely internal factors and external factors. Internal factors are physiological factors (students' physical condition) and psychological factors (students' mental condition). External factors come from outside students, namely family, school and community factors. However, there has been an increase in the value of each learning indicator. This increase indicates that students' physics abilities in solving problems and students' understanding of scientific creativity have also increased.

Table 3. Results of Scientific Creativity Analysis

Student's Name	Pre test		Post test		N-Gain	
	Score	Criteria	Score	Criteria	<g>	Criteria
PD1	70	Good	70	Good	0	Low
PD2	59	Fairly good	63	Fairly good	0.1	Low
PD3	68	Good	85	Very good	0.53	Medium
PD4	49	Fairly	68	Good	0.37	Medium
PD5	42	Fairly	54	Fairly	0.21	Low
PD6	60	Fairly good	94	Very good	0.85	High
PD7	50	Fairly	75	Good	0.5	Medium
PD8	55	Fairly	76	Good	0.47	Medium
PD9	57	Fairly good	80	Good	0.53	Medium
PD10	26	Not good	60	Fairly good	0.46	Medium
PD11	39	Not good	85	Very good	0.75	High
PD12	42	Fairly	70	Good	0.48	Medium
PD13	37	Not good	82	Very good	0.71	High
PD14	34	Not good	62	Fairly good	0.42	Medium
PD15	57	Fairly good	60	Fairly good	0.07	Low
PD16	50	Fairly	54	Fairly	0.08	Low
PD17	42	Fairly	58	Fairly	0.28	Low
PD18	65	Fairly good	90	Very good	0.71	High
PD19	42	Fairly	82	Very good	0.69	Medium
PD20	40	Not good	45	Fairly	0.08	Low
PD21	8	Not good	42	Fairly	0.37	Medium
Mean	47.24		69.29		0.41	Medium

The mean score Pretest	The mean score Posttest	N-Gain	Category
47.24	69.29	0.41	Medium

The results obtained on the pretest and posttest scores obtained n-gain values which can be seen in Table 3, namely <g> = 0.41 in the medium category. From these results it can be stated that there is an increase in student learning outcomes after using the dynamic fluid module developed using STEM-PBL. Based on the average pretest and posttest scores as well as the n-gain test, students' cognitive abilities, especially in scientific creativity, have increased compared to before they were taught using the dynamic fluid module developed using STEM-PBL. Analysis of the learning outcomes tests that have been carried out shows that learning using this module is effective because it is able to help students to achieve learning goals which direct students to undergo the learning process.

Based on the results obtained, the learning module developed can be declared effective because it meets the criteria for module effectiveness, namely there is a significant increase in the average pretest score to the average posttest score. The above illustrates that the dynamic fluid module developed using STEM-PBL can be said to be effectively used to increase students' scientific creativity.

Conclusion

This dynamic fluid module using STEM-PBL is effective in the learning process. This is supported by research findings, namely the effectiveness of the module as seen from the learning outcomes of effective students with an n-gain of 0.41 in the medium category. So the use of modules using STEM-PBL is suitable for implementation in schools.

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Conflicts of Interest

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