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# The Effectiveness of Using Physics Module with Problem-Based Learning to Enhance Critical and Creative Thinking Skills

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***ABSTRAK***

*Modul merupakan salah satu bahan ajar yang sangat membantu siswa dalam proses pembelajaran. Namun, modul-modul yang digunakan di sekolah masih kurang dalam memunculkan keterampilan abad 21, terutama dalam keterampilan berpikir kritis dan kreatif. Oleh karena itu, peneliti melakukan penelitian ini untuk menganalisis efektivitas penggunaan modul sebagai bahan ajar untuk meningkatkan kemampuan berpikir kritis dan kreatif siswa SMA. Metode yang digunakan adalah penelitian kuantitatif dengan uji prasyarat normalitas dan homogenitas serta uji N-gain untuk menguji keefektifan penggunaan modul dalam proses pembelajaran Fisika. Data yang digunakan adalah data hasil belajar siswa. Peneliti menggunakan uji normalitas Shapiro-Wilk yang menunjukkan nilai signifikansi pretest sebesar 0,153 dan posttest sebesar 0,052. Berdasarkan uji homogenitas menggunakan Levene's Test diperoleh signifikansi 0,615 dan menunjukkan data homogen. Rata-rata nilai N-gain untuk semua aspek keterampilan berpikir kritis adalah 0,68, sehingga peningkatannya berada pada kategori sedang. Sedangkan nilai rata-rata N-gain untuk semua aspek keterampilan berpikir kreatif adalah 0,47 dan peningkatannya juga dalam kategori sedang. Berdasarkan hasil penelitian dapat disimpulkan bahwa Modul Fisika dengan pembelajaran berbasis masalah telah efektif digunakan dalam pembelajaran Fisika untuk meningkatkan kemampuan berpikir kritis dan kreatif siswa SMA dalam kategori sedang.*

**ABSTRACT**

Module is one of the teaching materials that really helps students in learning process. However, the modules used in schools are still lacking in emerging 21st-century's skills, especially in critical and creative thinking skills. Thus, the researcher conducted this research to analyze the effectiveness of using module as a teaching material to improve critical and creative thinking skills of high school students. The method used is quantitative research with normality and homogeneity prerequisite tests and the N-gain test to check the effectiveness of using module in Physic learning process. The data used is the students' learning result. The researcher uses Shapiro-Wilk normality test which shows the significance value of pretest is 0.153 and posttest is 0.052. Based on the homogeneity test using Levene's Test, the significance is 0.615 and indicating homogeneous data. The average N-gain value for all aspects of critical thinking skills is 0.68, so the improvement is in moderate category. Meanwhile, the average N-gain value for all aspects of creative thinking skills is 0.47 and the betterment is also in moderate category. According to the results, it can be concluded that Physics Module with problem-based learning has been effectively used in Physics learning to improve critical and creative thinking skills of high school students in moderate category.

## 1. INTRODUCTION

Critical thinking is defined as a process of formulating systematic reasons keenly and cleverly where the students are demanded to think by conceptualizing, applying, analyzing, synthesis, or evaluating information collected through observation, experience, reflection, reasoning, or communication as a basis for determining the action. Critical thinking is really crucial for students because it allows them to be able to solve social, scientific, and practical problems effectively. Creative thinking skills are skills or abilities in solving problems and creating new ideas. The indicators of critical thinking according to Anggelo are: Analytical Skills, Synthesis Skills, Recognition and Problem-Solving Skills, Conclusion Skills, and Evaluation or Judging Skills. The development of collaborative learning management system using problem-based on cloud learning to enhance critical thinking (Boonprasom & Sintanakul, 2020). Problem-based learning pedagogy fosters students' critical thinking about writing (Kumar & Refaei, 2017). Thinking critically about critical thinking and problem-based learning in higher education (Thorndahl & Stentoft, 2020). Advancing Critical Thinking Through Learning Issues in Problem-Based Learning (Lawut et al., 2019).

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Creativity is not only about describing imagination or future, but also the ability to innovate an existing fact and to make a difference in an ongoing process (Johansson, 2020). A unique mental process that is different from the existing one, the result of a new innovation, and original from a specific thought is called creative thinking skills (Herdiawan et al., 2019). Creative thinking skills have several indicators such as fluently, flexibility, originality, elaborative, and evaluative. The creative thinking skills of students in Indonesia are still low, as shown in the Trends in International Mathematical and Science Study (TIMSS) data in 2011 and the Program for International Student Assessment (PISA) in 2012. The low creative thinking skills of students is due to learning strategies that still tend to be teacher-driven. center so that they have not been able to develop students' creative thinking skills (Festiana et al., 2014). Problem based learning through outdoor learning enhance creative thinking skills (Auliandari et al., 2019). Influence of problem-based learning model, discovery learning, and intellectual intelligence on creative thinking (Ladjar et al., 2017). Teaching creative thinking through blended problem based learning and history of science approach (Dogan, 2017).

One of the branches of Natural Sciences that explains various natural events in everyday life is physics. Natural events in physics are explained by concepts, theories and laws so that they can be accepted by the human mind (Kaniawati, 2017). Because physics is a branch of science, the nature of physics is often equated with the nature of science or science. The essence of physics is as a product (a body of knowledge), attitude (a way of thinking), and a process (a way of investigating). Applying physics to the module will have a good impact especially in Indonesia. Physics requires the students to skillfully apply the concepts and principles of science that they have obtained so they can be skillful students both in science and technology. The learning physics also focuses on analysis aspects which are included in higher-order thinking skills (HOTS). In addition, other skills needed in learning physics are critical thinking about a phenomenon and creative thinking in solving problems. It is very suitable applied in Indonesia which prioritizes providing stimulus that allows the growth of independent learning and learning experiences for students or commonly known as student centers. Students are encouraged to have higher-order thinking skills, 21st-century skills and literacy culture and Strengthening Character Education. One of suitable models is Problem-Based Learning (PBL) model. In PBL, learning is started by a problem that requires a solution. The knowledge element of learners related to how to describe the origin of thought about confusion, doubt, or both which are triggered by something specific (Yew & Goh, 2016). Students make a relationship between the problem and their prior knowledge to solve a problem or phenomenon. Besides, in PBL learning, students are also involved in group discussions, making it possible for students to understand a concept. Learning experiences can also help learners to develop an understanding of themselves and find ways to learn effectively. There are previous studies that have used physics as a module in learning, such as Validity of physics learning module based on problem based learning to improve students metacognitive skills (Ismiyati et al., 2019). The Iterative Development and Use of an Online Problem-Based Learning Module for Preservice and Inservice Teachers (Rillero & Camposeco, 2018). Gamification of icebreaking activities for mechanical engineering students embarking on a problem based learning module (Delaney et al., 2021).

PBL can provide 21st-century skills for students (Mayasari et al., 2016). Researchers state that PBL can develop 21st-century students' skills because it can link theory with practice and develop problem-solving skill, communication and collaboration. States that there are five phases of syntax in PBL, namely problem orientation, organizing students in researching, investigating, developing and presenting as well as analyzing and presenting (Zunanda & Sinulingga, 2015). In this learning, students must also collaborate with fellow students, this is in accordance with the demands of 21st-century skills. The outcomes of research conducted show that by learning using PBL method, students have a positive perception in their learning environment, are more confident and skilled in solving problems, have a positive attitude in lifelong learning and better processing skills. PBL learning enable students to use communication skills to express ideas, to organize and manage time, to develop inquiry skills, to do self-assessment and reflection skills, to practice group participation and leadership skills (Mayasari et al., 2016). Therefore, it can be said that module with PBL can be used to improve 21st-century skills. 21st-century skills are categorized into 4Cs, they are Communication, Collaboration, Critical Thinking and Problem Solving, Creativity and Innovation. One of 21st-century skills is about thinking skills which are skills or abilities in processing thoughts to find, explore and make decisions on a problem (Kurniasi & Arsisari, 2020). In 21st-century skills, there are critical thinking skills that are included in the HOTS section. Besides, HOTS characteristics also includes creative thinking (Kurniasi & Arsisari, 2020). Where exactly for enhance critical and creative thinking: the use of problem posing or contextual learning (Toheri & Winarso, 2018).

So, a Physics module with a Problem-Based Learning model is made because it is considered to be able to upgrade 21st-century skills, especially critical and creative thinking skills of high school students. Model of problem-based learning module on indonesian language affixation (Rofii, 2018). The study aims at discovering the effectiveness of using physics module with PBL model to improve critical and creative

thinking skills of high school students. The novelty of this research is the development of a problem-based physics module that is designed to be integrated with other learning media such as videos, simulations, and online evaluation with tools to integrate learning media outside the module with the module using a QR code that is inserted in the learning activities inside the module. The addition of the QR code feature is intended to make it easier for students to carry out learning activities.

## 2. METHODS

The research method used is quantitative research with prerequisite tests in form of normality and homogeneity tests. In addition, in order to see its effectiveness, the researcher uses N-gain test. The research subjects are 35 students of grade 10 MIPA-1 at SMA N 2 Surakarta. The research was conducted in October-November 2020. Instrument used is pre-test and post-test about critical and creative thinking skills of students. The researcher uses the normality test to check whether the data is normally distributed. The Shapiro-Wilk's normality test is used since the number of samples is less than 50. In order to calculate the data taken from the normality test, the researcher uses SPSS 18 program with a significance level of p = 0.05. The data used was the Physics pretest value data. In regards to the data collected. Homogeneity test is conducted to examine the similarity of variance, in other words the sample comes from a homogeneous population. The homogeneity test was carried out using the SPSS 18 program and using the Lavene Test by assuming that the samples came from the same population even though they had different means, they had the same variance. The module's effectiveness test was used to find out the benefits of problem-based Physics module in learning process to improve students' critical and creative thinking skills. The effectiveness of the physics module is calculated using the normalized gain. The normalized gain value was an analytical technique used to see the increase in a variable of students.

## 3. RESULT AND DISCUSSION

### Results

The module used previously had completely validated by experts and small-scale trials and the results showed that it is suitable to be checked through large-scale trials. The data about students' critical and creative thinking skills were measured using a pre-test and post-test. The result of students' critical and creative thinking skills is shown in Table 1.

**Table 1.** Data Summary of Test Results of Students' Critical and Creative Thinking Skills

| Kind of Test | Number of Students | Average | Minimum Value | Maximum Value |
|---|---|---|---|---|
| Pre-test | 35 | 62 | 50 | 73 |
| Post-test | 35 | 84 | 63 | 95 |

The analysis result of the normality and homogeneity's pre-test and post-test about critical and creative thinking skills of students is shown in Table 2.

**Table 2.** Analysis Result of Pre-test and Post-test Values

| Test | Significance | Decision |
|---|---|---|
| Normality | Pre-test = 0,153<br>Pos-ttest = 0,052 | $H_0$ Accepted |
| Homogeneity | 0,615 | $H_0$ Accepted |

The N-gain value obtained is 0.59. So it can be said that the increase in students' critical thinking test results is included in the moderate category (Gunawan et al., 2019). The next stage is analyzing every aspect of students' critical thinking skill. The average increase of each aspect of critical thinking is presented in Table 3.

**Table 3.** Average Improvement Result of Critical Thinking Aspects

| The Critical Thinking Skills Aspects | N-Gain Average | Category |
|---|---|---|
| Analysis Skills | 0,71 | High |
| Synthesis Skills | 0,91 | High |
| Problem Solving Skills | 0,55 | Moderate |
| Conclusion Skills | 0,62 | Moderate |
| Evaluation or Judging Skills | 0,59 | Moderate |

The analysis for each aspect of students' critical thinking and the average increase in each aspect of critical thinking skills is shown in Table 4.

**Table 4.** Average Improvement Results of Creative Thinking Aspects

| The Creative Thinking Skills | N-Gain Average | Category |
|---|---|---|
| Fluently | 0,59 | Moderate |
| Flexibility | 0,49 | Moderate |
| Originality | 0,47 | Moderate |
| Elaborative | 0,42 | Moderate |
| Evaluative | 0,38 | Moderate |

The validator has assessed the Physics module and it has been revised, then tested in the field to determine its effectiveness. The effectiveness of the Physics module was obtained from pretest and posttest data from research variables, namely critical and creative thinking skills. The pretest was carried out before the learning activities with the problem-based Physics module were carried out, and the posttest was carried out after carrying out the learning activities with the problem-based Physics module. The improvement of critical and creative thinking skills can be seen from the results of the calculation of the data from the large-scale trial in **Table 1**. The average result of the pretest is 62 and the posttest is 84. Previously, prerequisite tests were carried out, namely normality and homogeneity tests. The first prerequisite test is the normality test. The normality test used is Shapiro-Wilk, the significance value of pretest = 0.153 and posttest = 0.052, as shown in **Table 2**. It can be concluded that the data on critical and creative thinking skills are normally distributed. The next prerequisite test is the homogeneity test. In the homogeneity test using Levene's Test, the significance obtained is 0.615 indicating homogeneous data.

**Discussion**

The analysis results show that after the students use problem-based physics module, their critical thinking skills are increased in comparison with before using the module. The discussion about critical thinking skills' betterment by using problem-based physics modules is supported by some studies (Elizabeth & Sigahitong, 2018; Rahmat et al., 2019). They state that learning with Problem-Based Learning can improve students' critical thinking skills in moderate category. Moreover, the other study define that in developing problem-based teaching materials can upgrade students' critical thinking skills (Nizarullah et al., 2017). Although Problem-Based Learning is not a new model, the other research claims that it is ideal for enhancing critical thinking skills of students in Generation Z (Holland & Ulrich, 2016). Problem based learning to enhance students critical thinking skill via online tools (Hussin et al., 2018). The effect of problem based learning (PBL), online class and blended learning on thinking critical thinking of students (Kurniawan, Edy, 2015; Tiara & Usman, 2020). Development of problem-based learning module on electrolyte and nonelectrolyte solution to improve critical thinking ability (Sari et al., 2019). Enhancing critical thinking through the science learning on using interactive problem based module (Rubini et al., 2019). The effectiveness of Problem Based Learning - physics module with authentic assessment for enhancing senior high school students' physics problem solving ability and critical thinking ability (Suastra et al., 2019). The effectiveness of problem-based interactive physics e-module on high school students' critical thinking (Sujanem et al., 2020).

In **Table 3** shows, the improvement occurs in each aspect of critical thinking skills, with the highest increase is in the aspect of synthesizing skills with an average N-Gain of 0.91. The aspect that receives the lowest increase is in the aspect of problem-solving skills with an average N-Gain of 0.55. Lastly, the average N-gain value for all aspects is 0.68, so the betterment of students' critical thinking skills is categorized in moderate level. Module (novick learning) physics to improve critical thinking (Aji et al., 2018; Arifin & Retnawati, 2017). Developing Science Electronic Module Based on Problem-Based Learning and Guided Discovery Learning to Increase Critical Thinking and Problem-Solving Skills (Suryaningtyas et al., 2020). Based on the results of the N-Gain value, the increase in critical thinking skills occurs due to the use of modules designed with the Problem-Based Learning model related to aspects of critical thinking skills. Regarding to the results of the N-gain value, they show that the whole students' critical and creative thinking skills have improved by using problem-based Physics module as well as each aspect of students' critical and creative thinking skills. The highest improvement is in the aspect of fluent thinking skills with an N-Gain of 0.59. Whereas the lowest increase is the skill to assess or to evaluate with an N-Gain of 0.38, as shown in **Table 4** and the average N-Gain value for all aspects is 0.47, so the betterment in critical thinking skills of students is categorized in moderate level. Based on the results of the N-Gain calculation, improving students' creative thinking skills in learning using problem-based Physics modules is able to improve

creative thinking skills through problem-based learning stages that are associated with aspects of creative thinking. The betterment of creative thinking skills is also supported by a research by (Elizabeth & Sigahitong, 2018) which states that Problem-Based Learning affects the creative thinking skills of students. Besides, research from (Ersoy & Başer, 2014; Raehan et al., 2020; Ulger, 2018) state that students' creative thinking skills can be improved after applying Problem-Based Learning model in learning process. Using problem-based learning to improve students' creative thinking skills on water purification (Wahyu et al., 2016). Implementation of problem based learning model to improve creative thinking ability (Elizabeth & Sigahitong, 2018; Utari & Mustikawati, 2017). The Effectiveness of Problem Based Learning (PBL) in Increasing Student Creative Thinking and Self-efficacy (Risnawati et al., 2019). Implementation of Problem-Based Learning with Green Chemistry Vision to Improve Creative Thinking Skill and Students' Creative Actions (Nuswowati et al., 2017). According to the results of the N-Gain calculation, learning using problem-based Physic module can enhance students' creative thinking skills through problem-based learning stages which are connected to the aspects of creative thinking. The finding is supported by a research done by (Awal, 2017) who states that there is a betterment of students' creative thinking skills by using PBL which is categorized in high level.

The problem-based physics module used in learning is integrated with learning media that supports learning activities. With the link and QR code, it will make it easier for students to access teaching materials outside the module. In addition, this Physics module is equipped with learning steps and outputs aspects of critical and creative thinking skills. Link and QR code are also available to do posttest online. The addition of these features can help teachers in distance learning as it is today. Based on the discussion that has been carried out in the use of problem-based Physics modules during learning activities. Students' critical and creative thinking skills can be improved by using the PBL learning model. Syntax in PBL supports the improvement of critical and creative thinking skills. The use of learning media is also in helping students understand the learning material and practice skills in the use of technology by students.

## 4. CONCLUSION

This research is an effort to develop a module with the hope that it can be effective for use in physics learning. In the module development process, revisions and field trials are stages that must be passed so that the developed module can be used for effective learning which has an impact on improving physics learning outcomes. The Physics module with Problem-Based Learning has been effectively used in learning Physics to enhance the critical and creative thinking skills of high school students with moderate categories. There needs to be thorough preparation in learning using problem-based Physics module, so that the learning process can be done step by step and run smoothly. The materials and features in Physics module can be developed for other physics materials and can be updated by future researchers and teachers so that they can be used as teaching materials. The limitation of this developed module is that the use of learning media in the form of videos or simulations can only be accessed by pressing the link or scanning the QR code available with the QR code scanner application and requires internet access to open learning media outside the module. This module also has not been able to provide direct feedback and the storage media uses media outside the module. The implication is that it is necessary to make modules that are easily accessible online on other topics while still using the problem-based learning model (PBL) and wider trials to various schools so that it is known that effective learning methods can improve physics learning outcomes.

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