The development of robotic-based learning media in improving critical thinking abilities and learning outcomes of primary students

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Abstract. This study aims to develop robotic-based learning media that can improve students' critical thinking skills and students' learning outcomes. The method used in this research is the experimental research method, with 4th grade students of primary school as a subject. The instruments used include test, questionnaire, and observation sheet. The data analyzed were the results of the application in learning and student response questionnaires. The results showed that the developed robotic-based learning media could improve students' critical thinking skills and student learning outcomes with a gain value up to 0.85 (high criteria). The highest increase in thinking ability occurs in the indicator of analyzing and clarifying questions, answers, and arguments. Student learning outcomes after using robotic-based media showed a significant increase, this was indicated by the gain value reaching 0.78 (high criteria). The results of the response questionnaire showed a value up to 75.59%.

1. Introduction
The Curriculum as a tool, program, and educational design must be updated in regular basis and continuously according to students' needs and the development of science and technology. Operationally, curriculum development aims at optimally increasing the potential, intelligence, and interest of students according to the level of development and abilities of students so that educational goals are achieved Lapono [1]. From the psychological dimension, the curriculum in elementary schools is said to be relevant to students' needs if thinking skills are developed through the curriculum. The curriculum is considered irrelevant if students do not acquire thinking challenges during the learning process Hernawan [2].

One aspect of thinking skills that need to be emphasized in science learning in today's society with fast-pace technological change is thinking critically and solving problems. In the standard of competency for graduates of primary and secondary education units, it is stated that students must be able to show critical thinking and creative skills in building, using, and applying information about the surrounding environment to be able to solve problems BNSP [3].

One of the subjects that must be followed by elementary school students is science subject. According to Ardiyanti and Winarti [4], the science learning process cannot be carried out by just conveying information about the concepts alone. Students must also understand the process of the science phenomenon by sensing through demonstration and experimental activities. Therefore, science learning should be designed in such a way so that students get good and meaningful activities. According to Sund
and Trowbridge [5], the word science is "both a body of knowledge and a process". Experts also agree that the purpose of introducing science is to direct students to a positive attitude, through science education Dalgety, Coll and Jones [6].

However, science learning has not found significant results in education in Indonesia. This is because science learning is still carried out in conventional ways. Teachers still provide information to their students in a dominant and one-way manner. Lack of interaction between teachers and students made them less motivated, hence, the learning process becomes less meaningful. This is in line with the opinion of Thompson [7], which stated that currently, there are many theories about critical thinking skills, both traditional and contemporary. However, there are not many students who can master it. But, according to Cabera [8], mastery of critical thinking skills is not sufficient as a mere educational goal, but also as a fundamental process that allows students to overcome uncertainty in the future.

The low achievement of science in Indonesia is also influenced by the students' lack of critical thinking skills. The ability to think critically is needed by students to face various challenges. Critical thinking is a process that can be taught to students. However, the teacher must choose and determine the appropriate learning model for the students' development. Understanding enables us to understand the meaning behind the ideas that direct our lives every day. According to Elaine understanding reveals the meaning behind an event [9].

According to Dewey in Abidin [10], the primary learning activity that should be carried out in every subject in school is the one that can stimulate the students' minds to acquire all non-scholastic learning abilities. A significant effort following the above statement is to apply a constructivist learning model that is not teacher-centered but student-centered. In school students are expected to achieve learning objectives. One of the achievements in learning is good cognitive abilities. Bloom’s taxonomy identifies six categories of learning [11]: knowledge, comprehension, application, analysis, synthesis, and evaluation. The first two categories are aligned with lower-order cognitive skills (LOCS), while the last three categories require higher-order cognitive skills (HOCS)—skills overlapping with critical thinking and science process [12,13].

Based on the description above, the current learning process in primary schools must be modified. The learning process must be able to develop thinking skills, especially critical thinking skills in students. The material and stages of critical thinking skills developed in primary schools are simplified and adapted to students' cognitive levels and abilities that are still at the concrete operational stage according to Yaumi [7]. Basically Ennis develops critical thinking into two major aspects, namely the aspect of character formation (disposition) and aspects of abilities (abilities) [6].

Therefore, there must be the right solution in overcoming the problems that occurred to improve students' science learning outcomes. Learning aids in the form of appropriate and effective learning media that can create conducive learning atmosphere and encourage the success of the teaching and learning process is needed. Learning media is one of the factors that can increase student comprehension. By using learning media, the teaching and learning process will be more effective because the learning atmosphere will be fun and can increase student comprehension. Bahri in Susanto stated that media as a tool in the teaching and learning process is a fact that cannot be denied because it can help teachers to deliver learning materials optimally to students [14]. Teachers must be aware that without the help of media, learning materials will be difficult for every student to digest and understand, especially in intricate and complex subjects. With the use of media, there will be a trigger from teachers and students to interact, so that the teaching and learning process will be communicative. In addition, Susanto stated that the use of media will provide optimal interaction between teachers and students and establish good interactions between teachers and students in the teaching and learning process [14].

Based on the problems developed above, this research aims at discovering the development of critical thinking skills and mastery of science concepts in elementary school students using robotics-based media in elementary school science learning with the concept of physical environmental change.
2. Research methods
This research used a quantitative approach with pre-experimental methods. This method was chosen because purposive sampling was carried out so that there were factors that could not be fully controlled. According to Campbell and Stanley, pre-experimental research provides room for influential external variables from Ary et al. [15].

The designs used in this research were pre-test and post-test designs Creswell [16]. This research is conducted to test an idea, behavior, or procedure to determine its effect by changing a condition and observing its effect on other things. According to Arikunto, the research design used one class to provide a pre-test before treatment and a post-test after treatment [17]. The difference between the pre-test and post-test results is assumed to be the treatment or experiment's effect.

The sampling technique used in this research was purposive sampling. This technique is a sampling technique with specific considerations in accordance with the desired objectives [18]. The sample needed was determined in accordance with the problems to be studied with the consideration of certain reasons, namely academic achievement in science subjects and proactiveness compared to other classes.

3. Results and discussion
After conducting the research, it was found that the percentage of students' critical thinking skills before using robotics-based learning media was less than 55% for all research subjects, so it was included in the category of inadequate and very inadequate.

![Figure 1. Graph of students' initial critical thinking ability.](image)

Of all the students who were the research subjects, the initial critical thinking skills were still inadequate with the percentage of critical thinking abilities that were evenly distributed, none of which were significantly different. This can be due to the lack of learning activities that can hone the thinking skills of students. The research subjects came from classes with relatively good background and were proactive compared to other classes, so purposive sampling was included. However, if the learning process does not hone critical thinking skills, then the students' critical thinking skills are still considered inadequate.

The initial test (pre-test) was conducted to determine the initial critical thinking skills of students. After the pre-test was carried out, the treatment with robotics-based learning media was carried out. After all the learning activities were completed, students were given post-test questions to determine their final ability after being given treatment in the form of robotics-based learning media. It is also to determine whether there is an effect of the treatment given in the form of an increase in their critical thinking skills. The data on the post-test results from each student are as follows:
The data from the assessment of students' critical thinking skills before and after treatment showed an increase in students' critical thinking skills after using robotics-based learning media.

All students have increased their critical thinking skills after using robotics-based learning media. Six students experienced a significant increase, as evidenced by a high gain index value, which is more than 0.70. Simultaneously, 24 other students experienced an increase with a gain index value ranging from 0.30 to 0.69, which was in the 'quite good' category. The gain index value of the increase in critical thinking skills of all students is 0.85, which means that there is an increase in students' critical thinking skills after using robotics-based learning media and it is in the 'good' category.

Data from pre-test and post-test results were analyzed using SPSS 18 software with the paired sample t-test method to compare students' initial critical thinking skills and students' critical thinking skills after using robotics-based learning media. It is to test whether the difference is significant or not. In analyzing the data using the t-test, there are required conditions that must be met; the data must be normally distributed and homogeneous Arikunto [17]. Thus, the normality test using the Shapiro-Wilk was used because the number of research subjects was less than 50. Meanwhile, the homogeneity test was carried out using the variant test. Normality and homogeneity tests in data processing were carried out using the SPSS 18 software.

Based on the testing results for normality and homogeneity on the pre-test and post-test, the data is normally distributed and homogeneous. Therefore, the t-test can be carried out to determine the significance between the pre-test and post-test results. The resulting t value is 19.693, with a significance of 0.000 (< 0.005).

4. Conclusion
This research attempts to examine the use of problem-based learning in improving critical thinking skills and learning outcomes in primary school students. Based on the results and discussion, the following conclusions can be drawn:

- There was an average difference in students' critical thinking skills between the post-test and pre-test results. The pre-test results showed an average score of 14.733 with an average test score of 39. While the post-test results showed an average score of 26.37 with an average exam score of 69. The highest increase in critical thinking skills occurred in the indicators of analyzing and clarifying questions, answers, and arguments. This illustrated that there was an increase in students' critical thinking skills after using robotics-based learning media.

- There was an average difference in students' learning outcomes between the post-test and pre-test results. The pre-test results on learning outcomes got an average score of 16.74 with an average test score of 4.1855, while the post-test results on learning outcomes got an average score of 29.4 with an average exam score of 7.350. This illustrated that there was an increase in students' learning outcomes after using robotics-based learning media.
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