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The Effect of Double-Loop Problem-Solving Models on Students' Critical Thinking Ability

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Abstract

This study assesses the effect of double loop problem-solving models on students' critical thinking ability. The quasi-experiment with untreated control-group under the pretest-posttest design was used. The population included all students in class X of MIA SMAN 2 Aikmel with the total number of 123 people. The sampling technique was purposive, and the samples were 31 students were treated as the experimental group and others 28 students in X MIA 3were treated as the control group. The experimental group was treated with a double-loop problem-solving model while the control group with direct instruction learning. The instrument used was a critical thinking ability test of 10 items in which two items measured each indicator. Indicators measured were interpretation, analysis, evaluation, inference and explanation. The instrument test results showed that the ten items were valid and reliable so that they could be used in research. Research hypotheses were tested using pooled variance t-test. The results of the data analysis show that $t_{count} > t_{table}$ which means that H_0 is rejected and H_a is accepted, so it can be concluded that there is a significant effect of the double loop problem-solving models on the students' critical thinking ability.

Keywords: Learning model; Double-loop problem-solving model; Critical thinking ability

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INTRODUCTION

Critical thinking has become an essential aspect that students must-have in the 21st century to be competitive (Prayogi et al., 2018). Critical thinking is a component of higher-order thinking skills that can be mastered and taught. Critical thinking is reflective thinking focuses on deciding what to believe or not (Wahyudi et al., 2018*)*. Students who have the ability to think critically can formulate questions, study problems systematically, innovatively and can face challenges in an organized way (Men, 2017). Oktaviani (2016) stated that there is a significant relationship between critical thinking skills and learning outcomes. It means that if students have good critical thinking skills, the learning outcomes will also be good, and vice versa. When students' critical thinking skills develop, it makes it easier for them to understand a concept so that learning outcomes in the cognitive domain can also be improved.

Efforts to improve critical thinking skills continue to be studied and are still an important research concern. The phenomenon in schools shows that teachers are still constrained in efforts to improve students' critical thinking skills (Latifa et al., 2017; Nurmayani et al., 2018), the same thing was expressed by one of the physics subject teachers at SMAN 2 Aikmel that computer-based evaluations both daily and mid-term assessments in the form of multiple-choice were less able to measure students' critical thinking abilities in physics. The critical thinking abilities of students in physics at SMAN 2 Aikmel are trained by displaying examples of HOTS (High Order Thinking Skill) questions in accordance with the basic competency demands of the material to be delivered, but many students still do not understand the completion of the HOTS questions. The teacher's role is very important to guide and direct students in the learning process. The teacher should be able to create learning conditions that actively involve students both physically and mentally in the learning process. Teachers are required to have skills in choosing various models, methods, approaches, or learning strategies that are appropriate to develop the quality and potential of students, so that they are expected to improve student learning outcomes (Kirom, 2017).

One of the methods to improve students' critical thinking skills in physics is to use interactive and interesting learning models. Zamroni and Mahfudz (2009), revealed that there are four ways to improve students' critical thinking skills, namely by the use of specific learning models, giving assignments to critique books, the use of stories, and also by using the Socratic question model. One of the learning models that can be implemented to improve students' critical thinking skills is the problem-solving model. Trisnowati and Firdaus (2017) revealed that the problem-solving model teaches students to face and solve problems skillfully. The model was further developed into a double loop problem-solving model.

Shoimin (2014) revealed that the double loop problem-solving model could improve student analysis processes. Huda (2014) explains that the model was developed based on a theory by Argyris in 1976 that focuses on solving complex and unstructured problems to further serve as a kind of effective problem-solving tool. The syntaxes or steps of the double loop problem-solving model, according to Ngalimun (2012), are the processes of identification, causal detection (cause and effect), finding tentative solutions, considering solutions, causal analysis (causation) or other causal detection, and (f) planned solution selected. The steps of the double loop problem-solving model can train and improve students' critical thinking skills that can be measured by one of the indicators of critical thinking skills from Facione (2011), which consists of interpretation, analysis, evaluation, inference, explanation, and self-regulation. However, in this study, only five indicators of critical thinking ability are used, namely interpretation, analysis, evaluation, inference and explanation to measure students' critical thinking abilities.

Critical thinking ability can help students analyse information in the learning process. Afrizon et al. (2012) state that "critical thinking is a disciplined way of thinking used by someone to evaluate the validity of something (statement of ideas, arguments, and research)." Critical thinking is also deep reflective thinking in decision making and problem-solving to evaluate arguments, analyze situations, and draw appropriate conclusions (Stobaugh, 2013). A critical thinker is able to deduce what he knows, know the placement and how to use the information to be used in problem-solving, and can find relevant information sources that can support the problem-solving process (Adinda, 2016).

Previous studies by Pramana et al. (2014) shows that the use of the double loop problem-solving model can improve student learning achievement while the research of Fatmala et al. (2016) showed the influence of double loop problem-solving models on student cognitive learning outcomes that is there is an increase in cognitive learning outcomes. Both studies did not explicitly explore the effect of the double loop problem-solving model on students' critical thinking abilities, so it was important to conduct research on the effect of the double loop problem-solving model on the critical thinking skills of class X students at SMAN 2 Aikmel given that critical thinking skills are important to be taught as described previously. The steps of the double loop problem-solving model help students to better understand the problems and phenomena they encounter in the natural environment related to physics. This study aims to determine the effect of double loop problem-solving models on students' critical thinking ability.

METHOD

This research is a quasi-experimental with a non-equivalent design or also called an untreated control-group design, with a pretest-posttest. The research design adapted from Setyosari (2016) can be seen in Table 1.

Table 1. Experimental design

Group	*Pretest*	Treatment	*Posttest*
Experiment	O_1	X	O_2
Control	O_3	-	O_4

Annotation:

O : Observation (pretest-posttest)
X : Double-loop problem-solving model
- : Direct instruction

The populations were all (123) students of class X MIA SMAN 2 Aikmel in the 2018/2019 academic year which were divided into 4 classes. The sampling technique was the purposive sampling, with certain considerations, among others, the criteria for students to have taken harmonic vibration physics subject material, and the midterm exam scores were almost the same so that selected samples of class X MIA 2 were 31 students as the experimental class and X MIA 3 were 28 students as a control class. The test instrument measured the critical thinking abilities of students' physics. Sahidu (2016) defines "the test instrument is a set of tools intended to measure the achievement of learning competencies that have been previously planned". The test used was a type of test item as many as 10 item items based on critical thinking indicators from Facione (2011), namely interpretation, analysis, evaluation, reference and explanation that have been tested for validity, reliability, different power and level of difficulty so that it can be used for research. Two items measured each indicator. Instrument test results in this study are presented in Table 2.

Tabel 2. The results of the instrument test

No Item	Validity	Reliability	Items different power	Difficulty level
1	Valid	Reliable	low	moderate
2	Valid	Reliable	Moderate	moderate
3	Valid	Reliable	Moderate	moderate
4	Valid	Reliable	very high	moderate
5	Valid	Reliable	Moderate	difficulty
6	Valid	Reliable	Low	difficulty
7	Valid	Reliable	Low	difficulty
8	Valid	Reliable	Moderate	difficulty
9	Valid	Reliable	high	moderate
10	Valid	Reliable	Moderate	difficulty

The analysis of data was done by calculating the data normality test with the Chi-Square Test. According to Sugiyono (2011), the normality test is sought by using the chi-square equation as follows.

$$\chi^2 = \sum_{i=1}^{k} \frac{(f_o - f_h)^2}{f_h}$$

f_o = frequency of observations and f_h = expected frequency based on the theoretical normal curve frequency. Later, the homogeneity of the data was calculated using the variance test or the F-test. According to Riduwan (2014), F-test was formulated as follows.

$$F_h = \frac{\text{biggest variant}}{\text{smallest variant}}$$

The third stage was analyzing students' critical thinking skills that have been given a pretest and posttest based on five categories of critical thinking skills proposed by Setyowati et al. (2011). The guidelines for students' critical thinking categories are explained in Table 3.

Table 3. Guidelines for Critical Thinking Categories

Scale	Category
$81.25 < x \leq 100$	Very high
$71.50 < x \leq 81.20$	High
$62.50 < x \leq 71.50$	Moderate
$43.75 < x \leq 62.50$	Low
$0.00 < x \leq 43.75$	Very low

The last stage was testing the hypothesis using the pooled variance t-test. The hypothesis on the statistics tested was H_0: There is no influence of the two-round problem-solving model on the critical thinking abilities of physics in class X students at SMAN 2 Aikmel; and H_a: There is an effect of the two-round problem-solving model on the critical thinking abilities of physics in class X students at SMAN 2 Aikmel. This statistical hypothesis test was performed manually with the polled variance t-test equation as follows.

$$t_{count} = \frac{\overline{x_1} - \overline{x_2}}{\sqrt{\frac{(n_1-n_2)S_1{}^2+(n_2-1)S_2{}^2}{n_1+n_2-2}\left(\frac{1}{n_1}+\frac{1}{n_2}\right)}}$$

Annotation

$\overline{x_1}$= average score of the experimental class

$\bar{x}_2$= average score of the control class

S_1^2= experimental class variance

S_2^2= control class variance

n_1= the number of students in the experimental class

n_2= the number of students in the control class

The next value of t_{count} was compared with the value of t_{table} at a significant level of 5%. If $t_{count} > t_{table}$, then H_o was rejected and H_a was accepted and $t_{count} \leq t_{table}$, then H_o was accepted and H_a was rejected.

RESULTS AND DISCUSSION

The average score of students for the pretest and posttest in the experimental and control class can be seen in Figure 1 while the scores of each indicator of critical thinking skills of the pretest and posttest of the two classes can be seen in Figure 2. The research data in the form of the results of students' critical thinking skills in the experimental class and the control class were collected by giving a pretest and posttest. Data on students' critical thinking skills analyzed were data after treatment (posttest).

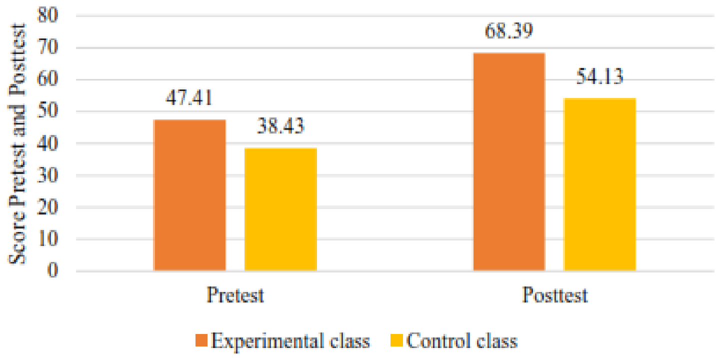

Figure 1. Average scores of student pretest and posttest

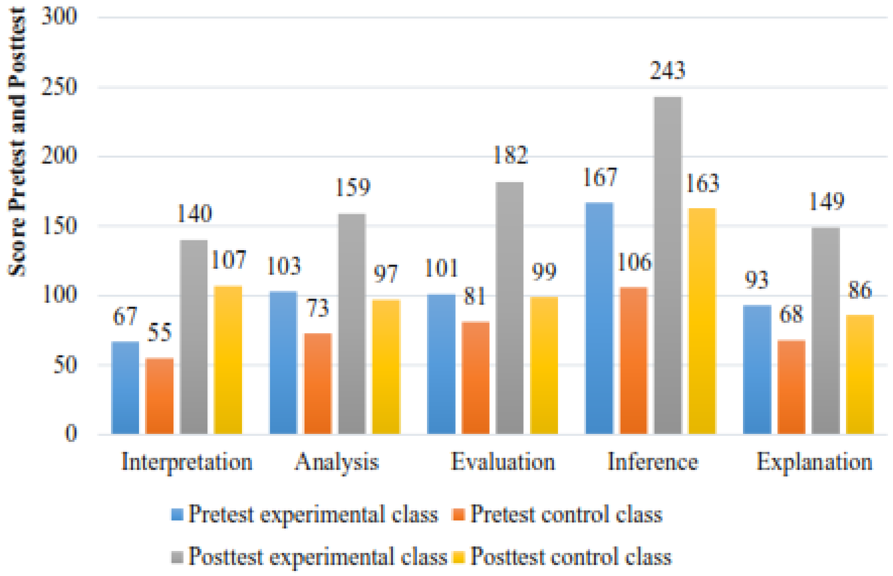

Figure 2. The score of students Pretest and Posttest

Pretest results show that the average value of students for the experimental class is 47.41, including the low category, while the control class is 38.43, including the very low category. The average posttest score of students for the experimental class that is 68.39 included in the medium category, while in the control class, 54.13 low categories. The students' critical thinking ability scores for the experimental class were higher than the control class for all indicators measured.

Differences in treatment given to students in the experimental class and the control class cause differences in the average score on the results of the posttest and the score of each indicator. Hypothesis prerequisite tests namely normality test and homogeneity test of pretest and posttest data (α = 0.05) of the students presented in Table 4 were conducted before the hypothesis was statistically tested.

Table 4. Normality and Homogeneity Test Results

Classes	Test	N	Normality test			Homogeneity test		
			$\chi^2{}_{count}$	$\chi^2{}_{table}$	Normality	F_{count}	F_{table}	Homogeneity
Experiment	pretest	31	3.9632	11.070	yes	1.72	1.93	yes
Control		28	6.7818		yes			
Experiment	posttest	31	2.4619		yes	1.84	1.89	yes
Control		28	5.6293		yes			

Based on Table 4, it can be seen that the pretest and posttest data of students' critical thinking abilities are normally distributed and homogeneous. The prerequisite test results indicate that hypothesis testing can be performed using the parametric statistical test of the t-polled variance test. Hypothesis test results using data posttest of students' critical thinking abilities in the experimental and control classes are presented in Table 5.

Table 5. Results of Hypothesis Test

Classes	N	Average	Variants (S^2)	t_{count}	t_{table}
Experiment	31	68.39	40.70	8.80	2.01
Control	28	54.13	74.99		

Table 5 shows that t_{count}> t_{table} is 8.80> 2.01 at a significant level of 5%. In accordance with the hypothesis testing criteria, if t_{count}> t_{table}, H_o is rejected, and H_a is accepted, which means that there is an influence of a two-round problem-solving model on the critical thinking ability of students in class X in SMAN 2 Aikmel. Hypothesis testing conducted showed that there was an influence of two-rounds of problem-solving models on students' critical thinking abilities in physics. This influence is in the form of the level of students' critical thinking physics in the experimental class is higher than the control class. The results obtained are in accordance with research conducted by Roliyani (2016) which states that the two-round problem-solving model can improve student learning outcomes and improve the quality of learning.

The control class taught using conventional learning makes the teacher as the center of information or facilitator so that students are less active in asking questions in the learning process or discussion. In addition, students also lack the courage to express opinions in class resulting in students' critical thinking abilities in physics being low for harmonic vibration material. Similar results were shown in previous studies by Sari et al. (2017) and Furoidah et al. (2017) that conventional learning in schools using the direct instruction model results in students tending to listen, taking notes which causes students to feel bored in learning so that student physics learning outcomes are low. Different from the stages or phases in the double loop problem-solving model. The first round consists of the identification phase, causal detection and tentative solutions. The first phase is the identification phase to train students' interpretation skills related to the problems presented. For example, in the first meeting, namely the characteristics of harmonic vibrations, the teacher presents the problem by giving questions after conducting a swing demonstration on a simple pendulum and vibration on a spring in front of the class. Next, students enter the second phase, the causal detection phase.

The causal detection phase of students is encouraged to find solutions to problems that have been identified previously to practice the ability to analyze the relationship between questions and concepts from students' initial knowledge so that tentative or temporary solutions are found. The third phase is the tentative solution of students proposing a solution which according to students, is the solution of the problem presented about the harmonic characteristic characteristics material by writing it down on paper or directly expressing an opinion in class, and this aims so that students have the ability of explanation. Proof of this tentative solution students will begin the second round of the learning process, namely the consideration of solutions (alternatives), other causal analyses, as well as the chosen solution.

The fourth phase of the double loop problem-solving model, namely the consideration of solutions that aim to gather as much information as possible to evaluate or test the truth of the statement used to convey thoughts on tentative solutions. For example, for the first meeting about the material characteristics of harmonic vibrations, students pay attention to the concepts explained by the teacher and the practicum conducted during the learning process. The results of this evaluation are used to determine whether there are other causal problems presented.

Students then enter the fifth phase, which is another causal analysis. Other causal analysis phases can practice inference skills because, in this phase, students conduct discussions about the problems presented from harmonic vibration characteristic material with classmates to determine or consider what information is needed to make conclusions based on concepts that have been obtained.

The final phase is the chosen solution in which students are trained to have the ability of explanation that is the ability to convey the results of thought or explain the conclusions of the solution of the material problems of harmonic characteristic given by the teacher based on the existing evidence, concepts and theories. Phases of learning using the double loop problem-solving model, according to Ngalimun (2012), can be used to train students' critical thinking abilities in physics. This is consistent with the results of research conducted by Anisah (2018) who revealed that the double loop problem-solving model could improve students' critical thinking skills because students in each cycle of the learning phase show high curiosity to find solutions to problems presented by the teacher.

In terms of each indicator measured, the indicators most mastered by students in both classes (experiment and control) for the posttest, namely inference indicators, because students in both classes actively participate in discussion activities to determine solutions to the problems presented by the teacher even in the class active control in discussion activities only categorized students have high initial knowledge. Students who are active in this control class contribute high scores to indicators of inference. This inference indicator is related to students' ability to determine or consider information used in drawing conclusions. This is in accordance with a study conducted by (Latifa et al., 2017 & Nurmayani et al., 2018) which states that the critical thinking indicators of inference that are most mastered by students because students at each meeting have been prepared to have the ability to inference that is making conclusions based on something that has been measured and observed.

The lowest indicator of critical thinking ability is mastered by students based on the posttest results for the experimental class, namely interpretation because students still have difficulty detecting or understanding the problems presented by the teacher both in the learning process or the questions have given while in the control class is the explanatory indicator because students are less able to explain the reasons of a solution presented and the learning process also shows that students are less courageous to express their opinions.

CONCLUSION

The elaboration of the results concludes of positive effect of the double loop problem-solving model on students' critical thinking ability in the moderate category. The double-loop problem-solving model has more prominent impact on students' critical thinking ability than direct instruction learning used as reference.

RECOMMENDATION

The double loop problem-solving model needs to be implemented for other physics materials because the double loop problem-solving model is new in physics learning and the research time is adjusted to the breadth and depth of the material to enhance the learning process.

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