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THE EFFECTIVENESS OF LEARNING INSTRUMENT OF MULTIPLE REPRESENTATIONS-BASED INQUIRY MODEL TO TRAIN CRITICAL THINKING SKILLS IN PHYSICS LESSON

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Abstract. This research was motivated by the lack of student critical thinking skills in physics. Two factors influencing physics learning achievement are internal factors consisting of verbal skills and abstraction, and external factors consisting of curriculum, learning method, facilities and infrastructure, as well as the accuracy of selecting teaching media/material. Multiple representations-based inquiry learning model allows student to express a concept in various form including verbal, graph, and mathematics. This learning model has been applied on 30 graders X-IPA in SMA Kemala Bhayangkari 1 Surabaya where their average pretest score was 31.11. After they participated in three physics lessons, by using a learning model and instruments with multiple representations-based inquiry approaches, their critical thinking skill is improved significantly become 82.67. Besides that, 87.6% of student likes the learning implemented on them. It could be concluded that learning instruments of multiple representations-based inquiry stated effective to train student critical thinking skills on physics of high school.

Keywords : *effectiveness, critical thinking, inquiry learning, multiplerepresentations*

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INTRODUCTION

This research was motivated by the lack of student critical thinking skills at the current (Khaeruddin, 2013). Within physics study, there are two factors influencing the lack of student learning achievement that are internal factor and external factor. The internal factors consist of verbal skills and abstraction, while external factors consisting of curriculum, learning method, inadequate facilities and infrastructure, as well as the incorrect of teaching media/material selected by the teachers in managing learning.

Research by Khaeruddin (2013), where it is a preliminary study of 31 teachers spread across six high schools in Makassar through the analysis of learning instrument documents, shows that the instrument as a reference within the teaching and learning process has not stimulated student critical thinking skills. The mentioned learning instruments found not completed yet with the implementation of critical thinking indicators.

One of the alternative learning could be applied to improve student critical thinking skills is by using the inquiry approach. Inquiry learning encourages students to use research procedures to identify the problems, ask the questions, propose the research steps, provide steady exposure, make predictions, and explain what supporting that experience (Binar, 2015).

The understanding of the student about Newton's law material is showed by their ability to transfer and connect macroscopic phenomena (observable events) and symbolic (formulas). The inability to represent one of both levels will affect the others (Ozkahraman & Yildirim, 2011).

Verbal explanation through the text will become easier to understand if the text is completed with pictures or graphics that correspond to the material. Students may use representations to support their understanding as they solve the problems or learning new concepts. In order to be proficient to solve the problem, several representations can be used. Multiple representations are the way to express a concept in various forms including verbal, graphic, and mathematics (Waldrip, 2006).

As explained by Khaeruddin (2016), multiple representations has three main functions: (1) as complement, to giving representation which contains complementary information or helps to completes cognitive process; (2) as interpretation limitation, used to limit the possibility of misinterpretation in using

other representations; and (3) as understanding constructor, used to stimulates student to construct their understanding and propose argumentation toward situation in depth.

The inquiry learning not only trains students to conduct experiments, but it also trains students capabilities to interpreting, managing, reasoning, and presenting information, so students are expected to be able to interpret and propose arguments based on experiments with inquiry activities by multiple representations approach (Suminar, 2016). Thus, multiple representations is a way of representing, symbolizing or expressing a concept by combining verbal, mathematics, picture, and graphic representations.

In order to understanding physics concepts, particularly on material of Newton's law I, II, and III, the student should be skilled in represented mentioned concepts in various ways (multiple representations). Research by Binar (2015), shows that physics learning by using an inquiry model can train the capability of multiple representations of high school students. The good multiple representations skill will ease to solve physics problems faced, thus expected to improve student critical thinking skills.

The similar thing also revealed by Rizal (2014), in his research about guided learning by using guided inquiry with multiple representations that can train science process skills and mastery of science concepts of junior high school students.

The focus of researches above had focused more on the effect of representation-based inquiry in understanding concepts, reasoning capabilities, and science process skills. Thus, researchers interested in conducting research with a multiple representations-based inquiry learning model to train the thinking skills of high school students.

METHOD

This research was learning instrument development adapted from the Four-D Models, which consists of four stages: define, design, develop, and disseminate. However, in this research, the dissemination was not conducted, because of the limited time of conducting research.

The research step was started by making syllabus, lesson plans, and textbook using an inquiry approach. All three learning instruments were validated by an expert in education and an expert in physics of State University of Surabaya.

The implementation of physics learning on the material of Newton's law I, II, and III with multiple

representations approach conducted during even semester in the academic year of 2017/2018. Teaching and learning process was conducted on 30 graders X in SMA Kemala Bhayangkari 1 Surabaya.

In order to know the preliminary data about student critical thinking skill then pretest question was given. Hereafter, students participated in the teaching and learning process for three meetings by using learning instruments with multiple representations-based inquiry. To determine students learning achievement, the posttest consist of six items was given. The mentioned posttest question is covering three indicators: analysis, interpretation, and inference.

Results of student critical thinking, pretest and posttest, based on the score of test result obtained and calculated using equation (1). The student is stated has critical thinking skills if achieved score more than 75, as criteria determined by SMA Kemala Bhayangkari 1 Surabaya.

$$Learning\ achievement = \frac{Score\ obtained\ by\ students}{Total\ Score} \times 100 \tag{1}$$

The pretest and posttest scores then tested by using paired sample t-test to determine the significance of student skill improvement in problem solving. A paired sampling t-test could be conducted with the condition that the data is distributed normally.

Normality test and paired sampling t-test conducted by using SPSS 22.0 by the original hypothesis reads: "there is no difference of average pretest and posttest score". The criteria of accepted or rejected original hypothesis are if significance less than α and significance degree $\alpha = 0.05$ (2-tailed), then the hypothesis rejected.

The improvement of student critical thinking skill was calculated by using equation (2), the comparison of actual gain scores with maximum gain scores, for then compared with category submitted by Hake (1999) in Table 1.

$$N - gain = \frac{Posttest\ Score - Pretest\ Score}{Maximum\ Score - Pretest\ Score} \tag{2}$$

(Hake, 1999)

Table 1. Criteria of N-Gain score

Score < g >	Criteria
$0,70 \leq N - Gain$	High
$0,30 \leq N - Gain < 0,70$	Moderate
$N - Gain < 0,30$	Low

(Hake, 1999)

In order to know student responses, the researcher gave questions through questionnaire sheet consist of seven items with the answer "Yes" or "No". The answers in the questionnaire sheets then analyzed using a descriptive qualitative method. Equation (3) was used to determine the percentage of every student answer.

$$Percentage = \frac{Number\ of\ respondents\ who\ answered\ items}{Total\ of\ respondents} \times 100\% \tag{3}$$

Table 2. Criteria of student responses score interpretation

Interval of average score (%)	Criteria
0-24.9	Not Positive
75-100	Very Positive

(Adapted from Riduwan, 2010).

RESULT AND DISCUSSION

The student test result shows that the average score of pretest is 31.11 and posttest is 82.67. The average pretest score indicates that three indicators of student critical thinking skills were poor. This can be interpreted that student critical thinking was trained yet.

To know the significance of student critical thinking improvement, after teaching and learning by using multiple representation-based inquiry approach, then performed normality test and paired sample t-test.

Result of the normality test shown in Table 3 indicated that data of pretest and posttest have a normal distribution.

Table 3 Normality test result of pretest and posttest data

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statisti		Sig.	Statist		Sig.
	c	Df		ic	Df	
Pretest	.147	30	.098	.942	30	.103
Posttest	.164	30	.039	.945	30	.124

The test result above shows significance $\alpha > 0.05$, has fulfilled the requirements to do paired sample t-test on pretest and posttest data. Result of the paired sample t-test shown in Table 4 also indicated a similar thing ($\alpha > 0.05$).

Table 4. Result of paired sample t-test

	Paired Differences				T	Df	Sig. (2-tailed)
	Mean	Std. Deviation	Lower Bound	Upper Bound			
Pair 1 Pre-Post	-57.9	4.68	-67.6	-56.1	-67.6	29	.00

After analyzing pretest and posttest score of student, appear that there is an improvement in critical thinking skill with average score of N-gain is 0.74 and included in high category. This improvement shows that teaching and learning by using multiple representations-based inquiry can train the critical thinking skills of students.

This is according to Binar and Soegimin (2015), which stated that the inquiry learning model able to improve student critical thinking skills. A similar result also showed by the research of Prabowo and Sunarti (2015), titled “The implementation of inquiry learning model on material of optics instrument to improve critical thinking skill of grader VIII in SMP Cendikia Sidoarjo”.

According to Chang (2005), where his research in the field of physics study show that constructivists can facilitate and involve students thinking and discussing actively in the classroom. Where ultimately, the students participate cognitively in the classroom because they have the opportunity to interpret, analyze, inference and share with their peers. The principle of constructivist learning theory is that the acquisition of knowledge is one of the conditions of developing critical thinking skills. Therefore, the teacher must have knowledge and understanding about student ways of thinking and how to develop thinking skills.

Further, Bruner in Nur (2008), suggested that students should learn through active participation with concepts and principles, so they gain experience and conduct the experiments that allow them to discover the principles by themselves.

Smart people can be interpreted that the person has many responses stored in his brain. If the response is interpreted as an impression, then learning is to put impressions into the brain, and make someone smart.

The impression referred here is of course in the form of science and knowledge obtained while studying (Rafafy, 2016).

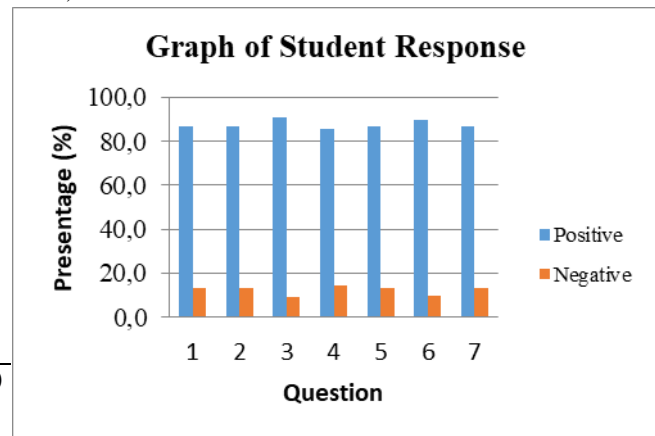


Figure 1. Student Response toward multiple representations-based inquiry learning

The graphic above shows student responses toward multiple representations-based inquiry learning model, where on average, 89.62% of students stated positive and 12.4% stated negatively. This result indicated that the majority of students have been successful to insert impressions into their brains and make them be more skilled in critical thinking.

CONCLUSION

Based on the formulation of the problem and guided discovery based SAS discussion to train scientific literacy In this research, the average score of student critical thinking skill improved with N-gain 0.74. this improvement included in the high category. By these, could be concluded that the developed physics learning instruments by using multiple representations-based inquiry learning model stated effectively to trains critical thinking skill of high school student. Besides that, the multiple representations-based inquiry learning that implemented along teaching and learning obtained positive responses by the students.

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