

How Are The Physics Critical Thinking Skills of The Students Taught by Using Inquiry-Discovery Through Empirical and Theoretical Overview?

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ABSTRACT

Previous research reports mention several learning models which are potential in improving students' thinking skills. This quasi-experimental research aims to determine the difference in critical thinking skills of the students who learned by using inquiry-discovery model and conventional learning model in class X. The treatment of this research was teaching physics by inquiry-discovery model and conventional learning model. The instruments of critical thinking skills were developed by the researcher and validated by an expert prior to use. The results of the research showed that there was a significant difference in the critical thinking skills between the experimental class and the control class. The result of critical thinking skills of the students in the inquiry - discovery class was higher than that of the conventional learning class. The research recommends that teachers empower HOTS ability of the students in the inquiry-discovery class, so that a meaningful learning and student-centered learning can be created. Future researches are needed to explore the contribution of inquiry-discovery model on students' critical thinking skills.

Keywords: critical thinking skill, inquiry-discovery, conventional, empirical and theoretical

INTRODUCTION

A number of learning skills need to be empowered in the education of the 21st century, one of which is the critical thinking skill, which is included as high-order thinking skills (Ikuonobe, 2001). These skills need to be instilled in every student to response to the extremely complex challenges (Halpern, 2003), along with the advance of science and technology which are changing the structure of society (Gumus *et al*, 2013). Critical thinking skill is a superior ability which plays an important role in all aspects of human life (Abed *et al*, 2015), problem solving (Hendricson *et al*, 2006; Carter *et al*, 2016) and decision making (Ku, 2009).

Critical thinking skills are necessary to be continuously applied in the learning process (Kealey *et al*, 2005). The emphasis is on the gold generation who continues their future life at the primary school to the university level. The purpose is to produce competent and skilled learners in solving problems in everyday life. The research results by Chartrand (2010) showed that 70% of senior high school graduates lacked the competence both involving the critical thinking skills and for 4 years college students only had 28% of critical thinking skills. The factors that cause the students' critical thinking skills are less empowered are that teachers do not have a good competence in designing learning (Aybek, 2007).

Teachers, who are the main pillars of education, need to make changes in the learning system. The empowerment of the students' critical thinking skills can be done in small groups and individuals in the learning activities in class (Aktas & Unlu, 2013). In relation to it, teachers have to design learning programs properly and engage students in each learning activity. Critical thinking skill can also be empowered by the teachers providing questions or problems that challenge students' thinking. Thus, the students' thinking structures will be more

Contribution of this paper to the literature

- Various high skill levels are often used by students in everyday life that can be utilized in improving the quality of learning through teacher creativity, such as students' critical thinking skill.
- Inquiry-discovery learning model through empirical and theoretical reviews can improve students' cognitive achievement on static fluid materials, which can empower students to solve real problems in everyday life and minimize student misunderstanding.
- Inquiry-discovery learning model through empirical and theoretical reviews is one of the most effective models for promoting problem-solving, reasoning, motivation and reducing student misconceptions that impact on improving the achievement of cognitive learning outcomes.

complex (Foster, 2009). The research by Whiley *et al* (2017) on the new students of environmental management in Queensland University found that before the students attended the lecture, they were given matriculation for a year relating to their critical thinking skills. This is because the student must be able to critically evaluate something in the workplace and society. The study can be applied in Indonesia, depending on the school principals and teachers who make the decisions in the learning process.

Another way to improve the students critical thinking skills is by using the appropriate learning model. The use of learning models can affect learning and determine the final results of the increase in the students' critical thinking skills (Mabrurroh & Suhandi, 2017). In relation to it, the learning model which is able to increase the students' critical thinking skills is inquiry-discovery (Hwang & Chang, 2011; Duran & Dokme, 2016), in which the students are actively involved in obtaining and discovering concepts or principles to empower their knowledge (Richardson & Renner, 1970). Inquiry-discovery learning model not only serves to guide students in understanding concepts but also familiarizes the students in completing tasks. The concepts found during the learning process are expected to reduce the physics misunderstanding of the students.

Various researches have reported the use of inquiry- discovery learning model without using students' critical thinking skills such as addressing misconceptions of junior high school students on the topic of wave and optical (Tompo *et al*, 2016), students' misconceptions on the moon phase (Radzi *et al*, 2017), academic achievement and retention (Balim 2009). Inquiry-discovery is the combination between discovery and inquiry learning. Discovery is the process of knowledge in which the students can assimilate concepts or principles. The knowledge process is observing, categorizing, making hypothesis, explaining, measuring, drawing conclusions and so on (Alfieri *et al*, 2011). Inquiry is an extension of discovery that is used more in-depth. It means that the process of inquiry consists of higher order knowledge, such as resuming an issue, designing investigations, conducting investigations, collecting data, analyzing data and drawing conclusions (Apedoe *et al*, 2006).

Inquiry-discovery learning model allows students to use their whole knowledge (cognitive, affective and psyhcomotor), especially the process of learning to find concepts or principles by themselves and trains their mental processes which is the characteristics of a scientist (Pedaste *et al*, 2015) and to train the students' problem solving skills (Onyancha *et al*, 2006). In the context of inquiry -discovery, students are given incomplete information by the teacher with the aim of encouraging them to make deductions and conclusion. In problem solving, students are directly involved in activities and individual and group discussion, with the help of teachers, students identify preconceptions. From their initial understanding, students move forward in building new knowledge with student-centered knowledge and encourage and stimulate students' minds because they need to use their reasoning skills to solve the problems posed by the teachers and then make conclusions (Radzi *et al*, 2017). Thus, this research aims at revealing the potential of inquiry-discovery in empowering the students' physics critical thinking skills.

METHOD

Research Type

This research is a quasi-experimental research that aims to uncover inquiry-discovery through empirical and theoretical review in empowering students physics critical thinking skills. Inquiry-discovery and conventional learning model were the independent variables, while the critical thinking skills were the dependent variable.

Population and Sample

Thep opulation in this research was the students of class X Science. The samples in this research were 67 students who were randomly selected. The sample of this research focused on 1 senior high school in Malang with a medium level school status. This research used two classes as the experimental class (n = 34) and the control class (n = 33). The students in the experimental class were taught by using inquiry-discovery learning model, while the students

Table 1. Score of Students' Critical Thinking Skills

Class	Sample	Critical Thinking Skills		Average Score
		High	Low	
Experiment	34	85	55	72.94
Control	33	75	55	65.45

Table 2. The Critical Thinking Skill score of high academic ability Students

Class	Sample	Critical Thinking Skills		Average Score
		High	Low	
Experiment	10	85	75	80.90
Control	10	75	70	73.18

Table 3. Score of the Critical Thinking Skills of the lower academic ability students

Class	Sample	Critical Thinking Skills		Average Score
		High	Low	
Experiment	10	70	55	65.00
Control	10	60	55	57.27

in the control class were taught by using conventional learning model. The physics class met for two hours per week for all students. The topic learned was about static fluid.

Data Collection

The data of the critical thinking skills were collected 2 times, in the form of pretest and posttest. The pretest was carried out before the treatment was given, while the posttest was carried out after the entire treatment was given. The treatment in this research was the use of learning models, namely inquiry-discovery on the experimental class and conventional learning on the control class. The physics learning, especially on the static fluid material, was conducted for 4 meetings. The learning activities have been ensured to follow the syntax of each learning model specified, to guarantee the consistency of the inquiry-discovery learning.

Research Instruments

The instrument used in this research was critical thinking skill test as many as 12 test items. The instrument was developed by the researcher, and it was validated by learning experts and theoretical physics experts from the State University of Malang and Kanjuruhan University. The instrument was developed by referring to the 5 indicators of critical thinking skills, namely the smoothness in giving simple explanation (*elementary clarification*), developing basic skills (*basic support*), drawing conclusion (*inference*), giving further explanation (*advanced clarification*), and setting strategies and tactics (*strategies and tactics*) (Ennis, 1993). The critical thinking skill instrument had been empirically tested, in order to obtain information regarding the validity and reliability, which was 0.70 and 0.91 respectively.

Data Analysis

The instrument used in this research was critical thinking skill test in the form of an essay test. The critical thinking skill test covered 5 aspects. The data were analyzed by using independent sample t-test to reveal a difference in the critical thinking skills of the students in the experimental class and in the control class. The data analysis were assisted with SPSS version 16 for Windows. Before the data were analyzed, the prerequisite tests, the normality and homogeneity, were performed. The results of the prerequisite tests indicated that the distribution of data in the control and experimental groups was normal and homogeneous.

FINDINGS

The description of the research results related to the main score of students' critical thinking skills, the critical thinking skill scores of higher and lower academic ability is presented in **Tables 1, 2, and 3**. **Table 1** shows that in the experimental class, the highest score of critical thinking skill was 85, and the lowest score was 55 with a mean score of 72.94. In the control class, the highest score was 75, and the lowest score was 55 with the mean score of 65.45.

Table 2 shows the critical thinking skill of the higher academic ability students. In the experimental class, the highest score was 85 and the lowest score was 75 and the average score was 80,90. In the control class, the highest score was 75 and the lowest score was 70 and the average score was 73.18.

Table 4. The Normality test of the Students' Critical Thinking Skills

	Class	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Critical Thinking	Experiment	.141	33	.087	.948	33	.107
	Control	.141	34	.095	.895	34	.004

a. Lilliefors signi Significance Correction

*. This is a lower bound of the true significance.

Information

LIDETR = Learning Inquiry-Discovery through Empirical and Theoretical Review

CL = Conventional Learning

Table 5. Homogeneity of the Critical Thinking Skills

	Levene's Test of Equality of Error Variance			
	F	df1	df2	Sig.
Critical Thinking Skills	.096	1	65	.757

Tests the null hypothesis that the variance of the dependent variable is equal across groups.

Table 3 shows the critical thinking skills of the lower academic ability students. In the experimental class, the highest score was 70 and the lowest score was 55 with the average score of 65.00. In the control class, the highest score was 60, the lowest score was 55, and the average score was 57.27.

The normality test was carried out using statistical Kolmogorov-Smirnov and Shapiro-Wilk at a significance level of 5% with SPSS 16.0 for windows. The results of normality test of the critical thinking skills are presented in **Table 4**.

Table 4 on the results of normality test using the Kolmogorov-Smirnov test showed that the significance value was greater than 0.05. Thus, the data of students' critical thinking skills are normally distributed, so that it could be proceeded to hypothesis testing.

Testing of Homogeneity

The homogeneity of this research was tested using Levene's Test of Equality of Error Variances to test of homogeneity variance, the first significance 5% with SPSS 16.0 for windows. As for the result of the test of homogeneity of variance-covariance critical thinking, presented in **Table 5**.

In **Table 5** test results of homogeneity variance from the data test critical thinking show significance were greater than 0.05. Thus can be concluded that data test level think critical thinking come from the homogeneous.

Testing of Hypotheses

The testing of hypotheses in this research using the analysis Anova in the level of significance of 5% with SPSS 16.0 assistance program for windows. Hypothesis in this research was "critical thinking skills students learned by learning inquiry-discovery through empirical and theoretical, review higher than students who learn physics to conventional learning. The testing of hypotheses the research was done in order to provide of statistically, do hypothesis advanced by in this research may be accepted or rejected. The results of the analysis ANOVA.

Hypothesis tested by analyzing couples hypothesis zero of (H_0) and hypotheses comparison (H_1) as follows.

H_0 = no the difference in the think critically, between students learned by learning discovery through empirical and theoretical review with students of learned by conventional learning.

H_1 = level think critically, students who studied to learning discovery through empirical review and theoretical higher than students learned by conventional learning.

Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roys's Largest Root on effect of learning all shows a figure significance (sig.) = 0.000 < 0.05 and at **Table 6** which show source of learning is against the dependent variable for the level of think critically Obtained F = 18.354 with significance (sig.) = 0.000 < 0.05. Thus Spake H_0 rejected and H_1 accepted, this means shows that the critical thinking who Learns by learning inquiry-discovery through empirical and theoretical review, higher than students who learn by learning conventional seen from the average level of think critically students who learn by discovery learning through is 68.76 while students who Learns by conventional learning is 65.58.

Table 6. Pillai's Trace, Wilks' Lambda, Hotelling's Trace, dan Roys's Largest Root on effect of Learning

	Effect	Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	.995	6.016E3 ^a	2.000	64.000	.000
	Wilks' Lambda	.005	6.016E3 ^a	2.000	64.000	.000
	Hotelling's Trace	187.995	6.016E3 ^a	2.000	64.000	.000
	Roy's Largest Root	187.995	6.016E3 ^a	2.000	64.000	.000
Learning	Pillai's Trace	.243	10.275 ^a	2.000	64.000	.000
	Wilks' Lambda	.757	10.275 ^a	2.000	64.000	.000
	Hotelling's Trace	.321	10.275 ^a	2.000	64.000	.000
	Roy's Largest Root	.321	10.275 ^a	2.000	64.000	.000

* p < 0.05, ** < 0.001

DISCUSSION

The results of the research indicate that the critical thinking skills of the students taught by using *inquiry - discovery* model through empirical and theoretical study are higher than those of the students taught by using conventional learning. The students taught by using *inquiry-discovery* learning participated more actively in learning. This is because the students were given the opportunity to find their own knowledge to be conveyed through direct experiments. Sweller *et al* (2007) states that high academic ability students are able to follow the learning well, compared to the low academic ability students. Therefore, the *inquiry - discovery learning* can improve the ability of the low academic ability students (Alex & Olubusuyi, 2013). *Inquiry - discovery learning* facilitates students to learn through active involvement, and teachers encourage students to have the experience and conduct experiments that enable them to discover concepts or principles without requiring the help of a teacher (Saab *et al*, 2005).

A teacher must try to use guided discovery approach to engage students in problem-solving activities (Onyancha *et al*, 2006), independent learning, critical thinking and understanding, and creative learning. An important thing in *discovery* learning is that students are given the opportunity to do experiments, so that their curiosity grows better when doing experiments, then they find hypotheses and have discussion of the results of experiments conducted. Based on the advantages that have been explained, the *inquiry-discovery* learning through empirical and theoretical reviews provide better results in the achievement of the students' critical thinking skill than the students taught by using conventional learning.

The average difference in the students' achievement is due to the different treatment between the experimental class and the control class. *Inquiry - discovery* is a learning model which is based on discovery and experience as on the static fluid material about Archimedes law. In the learning, the students conduct an experiment to know the Archimedes law through the practical work they are doing, so that they can easily remember the Archimedes law. Students understand the concepts of Archimedes easily based on their practicum experience. Thus, the achievement of the students who learned by using *discovery* learning is better than those who learned by using conventional learning.

When conducting an experiment in the experimental class, the students were more active and enthusiastic in following the learning activities, and the students' curiosity was higher. The students were very active and happy as they could find the Archimedes law by themselves through experiments. According to Makoolati *et al*, (2015) *discovery* learning provides opportunities for student-centered activities and allows students to learn from not only teachers as the only source of learning.

The advantages that the students get from this learning model are that it can trigger the students curiosity and independent learning in problem solving. Therefore, in this research, the students who learned by using *inquiry - discovery* through empirical and theoretical reviews had higher critical thinking skills than those who learned by using conventional learning. As already known, physics is a science learning category that requires experimental activities to understand the concepts or principles. In addition to increasing critical thinking skill, it also increases students' learning achievement, because the students independently learn to get the results of the experiment which they do to prove a theory. This process can help students develop their knowledge because the conduct the experiment by themselves which is later perfected by the teacher's explanation. In such learning, the teacher is not the main icon of learning, but the students are. Thus, the students have a big opportunity to construct their critical thinking.

CONCLUSION

Inquiry - discovery learning through empirical and theoretical review generates higher critical thinking skills than the conventional learning does. Therefore, the *inquiry - discovery* learning is recommended for the learning of other physics materials to improve the students' critical thinking skills. Future researches are expected to do comprehensive overview on the other high order thinking skills.

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