INQUIRY-SCAFFOLDING LEARNING MODEL: ITS EFFECT ON CRITICAL THINKING SKILLS AND CONCEPTUAL UNDERSTANDING

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Abstract: *This study aimed to examine the effect of inquiry-scaffolding on critical thinking skills and conceptual understanding. The research design used was a mixed-method embedded experimental model. The samples were 64 students. Two-way ANOVA test results for critical thinking skills and conceptual understanding are the same, where the significance value of the learning model = 0.00 (smaller than the alpha value of 0.05). It means that there are differences in critical thinking skills and conceptual understanding of students who learn by inquiry-scaffolding models (IS) with conventional models. The interaction value between the learning model and the initial ability to critical thinking skills (CTS) is 0.502, while the conceptual understanding is 0.788. It means that there is no interaction between the learning model and the initial ability to CTS, or conceptual understanding. The results of advanced tests with the Tukey test prove that CTS and the conceptual understanding of students with high ability who experience learning with IS are higher than students with high ability in conventional learning. The same thing also applies to students with low initial ability. Thus, it was concluded that the learning model with an inquiry-based scaffolding technique was superior in improving CTS and conceptual understanding, on students with high and low initial abilities. Therefore, this technique can be used in other learning by using different moderator variables.*

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INTRODUCTION

Learning physics is considered by many students and almost everyone is a field of science that requires a good conceptual understanding that trains students to think constructively, analytically, logically, and systematically (Shishigu, Hailu, & Anibo, 2018; Latifah et al., 2019). The experts explain that learning physics is one of the sciences that is considered very difficult, especially because learning is oriented towards various representations that are still abstract (Klein, Viiri, & Kuhn, 2019).

The main objective of learning physics in the current era is to provide knowledge experience, practice critical and creative thinking skills and be able to produce innovative work (Whiley, Witt, Colvin, Sapiains Arrue, & Kotir, 2017). In constructing the reconstruction of knowledge, brilliant thinking and analysis are needed in the form of critical issues to correct conceptual errors that are still wrong, to fit the views of experts. (Doleck, Bazelais, Lemay, Saxena, & Basnet, 2017). Critical thinking cannot be obtained easily, therefore it takes a lot of intellectual exercise in reconstructing the brain to think. Critical thinking skills (CTS) train students to conduct investigations, analyze information and reflect. Furthermore, CTS is also a basic skill needed in the world of work

including decision making, leadership and scientific reasoning so that it leads to professional success (Kola, 2019). The results of research in Hong Kong explained that the student learning environment greatly influences student CTS. Therefore, critical thinking plays a role in mediation, related to the relationship of the learning environment, conceptual understanding, and academic skills of students (Tiruneh et al., 2016).

The research report provides information that students' critical thinking skills are still very low. As evidenced by the results of research in several cities in Indonesia, including in Ambon (Leasa, Talakua, & Batlolona, 2016), Malang (Mahanal, Zubaidah, Sumiati, Sari, & Ismirawati, 2019), Semarang (Muhlisin, Susilo, Amin, & & Rohman, 2016) and Karas City (Irwan, Maridi, & Dwiastuti, 2019). Also, in several countries in the world, among others, Turkey, which has entered the category of developed country (El Soufi & See, 2019) and several developing countries such as Vietnam (Das, Nguyen, Nguyen, Nomikoudis, & Van, 2019) and Thailand (Ruchiwit, Patchotasingh, & Phanphairoj, 2019).

CTS is very much related to conceptual understanding. Conceptual understanding is needed as a basis for solving problems, thinking critically and creatively. Specifically, that conceptual understanding transforms knowledge into multiple representations so that new concepts are born (Kadir, Yeung, & Diallo, 2017). A person in achieving high levels of thinking is built from the foundation of a conceptual. Therefore, in improving CTS, it is necessary to hone cognitive knowledge by building internal conceptual. The teacher as a facilitator in learning, need to consider the initial ability of students that will facilitate in accommodating students so that learning objectives will be achieved (Kruit, Oostdam, van den Berg, & Schuitema, 2018).

The results of previous studies inform that the level of students' conceptual understanding of physics is still very low because teachers give a lack of training in students' critical thinking skills (Dwyer, Hogan, Harney, & Kavanagh, 2017). Besides, in the learning process, teachers tend to pay less attention to the initial abilities of students. Poor conceptual understanding will cause students' CTS levels to also below (Tseng, 2019).

Besides paying attention to initial abilities, the teacher also needs to choose the right learning model in improving CTS and students' conceptual understanding. One recommended learning model is the inquiry learning model since it offers student-centered (Fernandez, 2017). Experts develop inquiry learning models to improve students' innovation skills in thinking and solving problems (Acar & Tuncdogan, 2018). Inquiry learning requires students to work collaboratively in asking questions, making temporary hypotheses, designing an investigation, developing results and findings in accordance with what is obtained and building communication (Suárez, Specht, Prinsen, Kalz, & Ternier, 2018). In improving CTS and students' conceptual understanding, scaffolding techniques are used in its application. This is because scaffolding can motivate students to learn (Hsu, Lai, & Hsu, 2015). Scaffolding technique as one of the aids in accordance with the physics learning characteristics to practice new skills in solving physical problems that are considered difficult (Dawkins, Hedgeland, & Jordan, 2017). By scaffolding-assisted learning, students get more detailed directions and instructions from the teacher at the time of learning, so that patterns of interaction are more directed in achieving the objectives to be achieved. Learning assistance is an indispensable thing. This is because the composition of students in the class varies from aspects of cognitive

abilities. This assistance is given to students in accordance with the level of ability seen from the initial ability of students.

One of the recommended learning models is an inquiry with scaffolding techniques. Based on the results of previous studies, many experts have developed similar studies but with a different focus. Researches by examining the effect of Inquiry-scaffolding (IS) on students' critical and conceptual thinking skills are still limited. They are still being developed with different variables between inquiry and CTS (Mercuri & Mercuri, 2019), IS to improve scientific argumentation (Andrews-Larson, McCrackin, & Kasper, 2019) and IS to increase critical thinking in asking scientific questions (Brownfield & Wilkinson, 2018). Thus, a deeper exploration of this problem was carried out. Therefore, the purpose of this study was to analyze the effect of the Inquiry-scaffolding learning model on the critical thinking ability and physics conceptual understanding of students on static fluid material.

METHODS

The research method used was a mixed-method embedded experimental model to explore the research subject completely. The research design can be shown in Figure 1. The study was conducted in one of the medium level schools based on the categorization of the Malang City Education Office. One of the reasons for choosing the school is because of the heterogeneous characteristics of students without an entrance test to get students who excel when graduating from elementary school. The samples in this study were 64 students consisting of 23 male students and 41 female students. The study was conducted in class VIII at Public Junior High School 3 Malang. To measure critical thinking skills and conceptual understanding, two classes were used. Class $VIII_5$ is as an experimental class that was named as "Pascal" with 32 students and $VIII_6$ as a control class that was named "Archimedes" with 32 students. The technique used in research sampling was purposive sampling. Through preliminary tests in the Pascal and Archimedes classes, it was proven that students had the same initial abilities.

The instrument used for research to measure student CTS was in the form of a test item with 10 items with a score level of 0-5 with a clear description of the answers. The questions for conceptual understanding used a multiple-choice test pattern of 20 items. The technique used in data collection was in the form of in-depth interviews related to student answers and confirmed learning patterns with IS. In each meeting, observations were made on the feasibility of learning and the material being taught. The documentation of student activities from the pretest and the learning process of each meeting to the posttest was used. The data analysis technique used was a two-way ANOVA test with the assistance of SPSS 16.0 for Windows. Before testing the hypothesis, the requirements that are met are normality and homogeneity testing with the Kolmogorov-Smirnov test with the assistance of SPSS 16.0 for Windows. The following is a research flow chart shown in Figure 1.
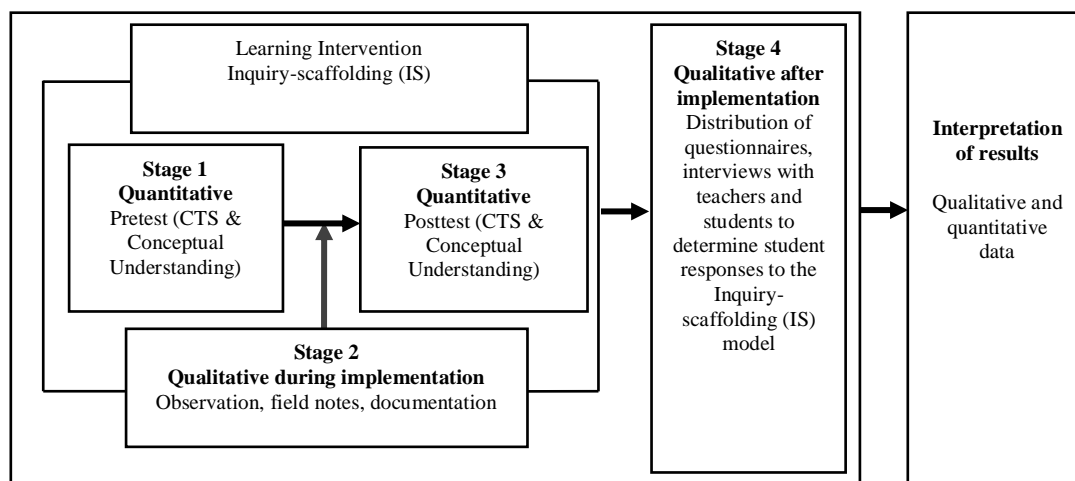
Figure 1. Research design

RESULTS AND DISCUSSION

The pretest and posttest scores in the Pascal class to measure critical thinking skills (CTS) and conceptual understanding (CU) before and after were given in-depth to students. The learning material was static fluids as shown in Table 1.

Table 1. Description of Pascal and Archimedes class scores

Measuring variable	Pascal		Archimedes	
	Pre test	Post test	Pre test	Post test
CTS	36.84	79.21	37.09	67.34
CU	36.71	77.81	46.25	68.59

The results of Table 1 show that there are differences in CTS and CU of students in the Pascal and Archimedes classes. The Pascal class is higher than the Archimedes class. The findings found that students feel more helped in their learning with IS. Students find good learning patterns to stimulate CTS and CU. At the beginning of learning, students still felt confused. At the next meeting, students were so enthusiastic about learning. Students' CTS and CU increase at the posttest after being given treatment. It means that the learning models and techniques applied to the learning process affected CTS and CU. The IS model can increase conceptual understanding because the model requires students to learn to find by

themselves to gain more knowledge by giving a problem and solve it based on the knowledge they have (Diani et al., 2018). When students experience difficulties in learning, it is necessary to have scaffolding, as a medium that aims to help students who have learning difficulties so that they can solve a problem. This is proven by the N-Gain of student scores shown in Figure 2.
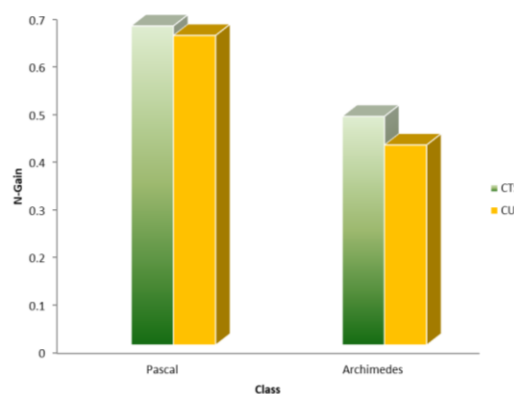

Figure 2. N-Gain of CTS and CU in Pascal and Archimedes classes

The data tested is the posttest data to test the hypothesis using the two-way ANOVA test. The N-Gain Test using the Independent Sample Test was used to see improvements in CTS and conceptual understanding before and after treatment.

The results of the normality test sample data showed that conceptual understanding's significance coefficient

of the experimental class was 0.661, the critical thinking with significance coefficient of 0.925, the conceptual understanding of control class with significance coefficient of 0.282, and the critical thinking of the control class with significance coefficient of 0.879. Thus, it can be said that the data were normally distributed since they were greater than 0.05. Homogeneity test results between the sample data in this study showed that a significance coefficient of 0.780 for conceptual understanding and 0.169 for the CTS. Based on the results, it shows that the data were homogeneous with the analysis result is greater than 0.05. The data in this study have fulfilled the prerequisite test. The sample data were normally distributed and came from a homogeneous group. Therefore, the data was then tested in advanced. The advanced test results are explained in the description form.

The results of the hypothesis test are as follows.

1. Hypothesis 1
   Hypothesis 1 in this study was analyzed using the two-way ANOVA statistical test.
   The coefficient of significance got 0,000 or sig <0.05 so H0 was rejected or H1 was accepted. There were differences between the CTS of students who learned with the IS model and conventional learning.

2. Hypothesis 2
   The significance coefficient got 0.502 or sig> 0.05 so that H0 was accepted or H1 was rejected, so it was concluded that there was no interaction between IS and initial ability of CTS.

3. Hypothesis 3
   The third hypothesis test in this study used the Post Hoc advanced test. The significance coefficient got 0.013 or sig <0.05 so H0 is rejected or H1 is accepted. This means that CTS students with high initial abilities who learned by using the IS model were higher than students with high initial abilities who learned using conventional learning.

4. Hypothesis 4
   The fourth hypothesis test in this study used the Post Hoc advanced test. The significance coefficient got 0.013 or sig <0.05 so H0 was rejected or H1 was accepted. Thus, CTS students with low initial abilities who learned using the IS model were higher than students with low initial abilities who learned using conventional learning.

5. Hypothesis 5
   The coefficient of significance got 0,000 or sig <0.05 so H0 was rejected or H1 was accepted. In conclusion, there was a difference in the conceptual understanding of students who learned with the IS model and conventional learning.

6. Hypothesis 6
   The significance coefficient got 0.788 or sig> 0.05 so H0 was accepted or H1 was rejected. In conclusion, there was no interaction between IS and initial ability to students' physics conceptual understanding.

7. Hypothesis 7
   The seventh hypothesis test in this study used the Post Hoc advanced test. The significance coefficient got 0.013 or sig <0.05 so H0 was rejected or H1 was accepted. It means that the physics conceptual understanding of students with high initial abilities who learned using IS was higher than students with high initial abilities who used conventional learning.

8. Hypothesis 8

The eighth hypothesis test in this study used the Post Hoc advanced test. The significance coefficient got 0.006 so H0 was rejected or H1 was accepted. Thus, the physics conceptual understanding of students with low initial abilities who learned using IS was higher than students with low initial abilities using conventional learning.

N-Gain Test Analysis Results for Student CTS.

The results of the Independent Sample Test show that the significance coefficient value was less than 0.05 (sig <0.05), which was 0.000 so that it can be concluded that there was a very significant difference in the ability to think critically between students who learn using IS learning and students who learn using conventional learning. Independent Sample Test Results show the value of the coefficient of significance in the line between groups was smaller than 0.05 (sig <0.05) which was 0.007 so it can be concluded that there was a very significant difference in the ability of physics conceptual understanding between students who learned using IS and students who learned using conventional learning.

The success of IS in improving CTS and students' physics conceptual understanding was supported by steps of inquiry learning that involve students actively and collaboratively in learning so that students found the right formula. Also, scaffolding could help students in improving student CTS. Learning through a practicum in the IS occurs the interaction of discussions with groups to build cooperation and exchange opinions to solve the problems faced. Also, there was teacher assistance to direct and guide students so that learning was more directed and systematic. The learning process carried out to take place well when students are allowed to ask questions that are considered very important to build conceptual knowledge. Students felt valued and respected during the learning process. This pattern was a humanist learning process that makes simple learning more meaningful (Batlolona, Baskar, Kurnaz, & Leasa, 2018).

Other findings also showed no interaction between the IS learning model and initial ability to CTS and students' physics conceptual understanding. Thus, it can be said that students with high initial abilities both those taught using IS and those who learned using conventional learning will still be higher than students with moderate initial abilities, and students with moderate initial abilities will still be higher than students with low initial abilities. Students with high initial ability had an intention from within oneself to study even harder, while students with low initial ability did not like physics because it was difficult. Also, some students explained that they preferred kinematics and electricity. They felt the material was very pleasant and the teacher's learning patterns were more detailed and related to digital learning that describes the concept. Students with high initial abilities tend to continue to improve their academic skills. The findings of previous experts explain that there is no interaction between the initial ability of students and learning models on student physics learning outcomes (Parappilly, Schmidt, & Ritter, 2015).

The results showed that CTS and physics conceptual understanding of students with high initial abilities who learned using IS learning were higher than students with high initial abilities who learned using conventional learning. The increase of CTS and physics conceptual understanding of students with high initial abilities who learned by using IS learning was due to several factors. High initial
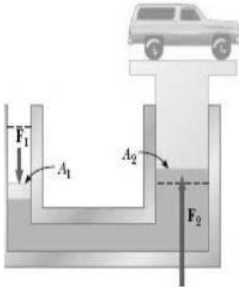
ability students who learned using IS learning to tend to have their learning intentions and were supported by learning models that provide opportunities for students to play an active role in learning. Activities in IS learning required students to concentrate fully on learning. Students practiced solving problems independently to give direction to students to solve these problems. This was in accordance with the advantages of scaffolding, which helps students' failure in cognitive development.

The results showed that CTS and physics conceptual understanding of students with low initial abilities who learned using IS learning were higher than students with low initial abilities who learned using conventional learning. Low initial ability have the opportunity to play an active role. The phases in the inquiry learning model that were collecting data and testing hypotheses provided an opportunity for them to explore knowledge and discuss it with peers. Thus, forming students in understanding concepts, reconstructing new theories and looking for alternative solutions

Critical thinking skills were directed at high thinking. This can be seen in the recorded answers to students where they were able at a very critical level. Critical thinking was based on a good conceptual understanding.

Table 2. Results of recording answers with are learning to improve CTS and students' conceptual understanding

Question	Students' answer	Categories
Hydraulic car lifting machines are widely used in a car wash. The picture below shows the scheme of the car lifting machine. (Source: Serway & Jewett, 2014) How is the principle of the car lifting machine?. Explain by observing the picture above.		Very Less critical
		Less critical
		Quite critical
		Critical
		Very Critical

Assistance from the teacher as a guide, when making observations has a positive impact on the learning success of students who learned using IS. Also, sufficient practice exercises cause students to experience an increase in CTS grades and conceptual understanding. This was because inquiry facilitates students thinking at a high level in solving physics problems (Roksa et al., 2017). In the initial learning, in Thailand, 36.5% of 6,235 students who were taught using conventional learning in 10 Provinces obtained the average score and only 2.09% of them passed. It is a relatively low achievement of learning outcomes. After approaching the inquiry, students experience a fairly high increase (Changwong, Sukkamart, & Sisan, 2018). By the stages of learning and using scaffolding techniques, students felt helped in learning and got better ability to reconstruct physics conceptual.

Communication skills and alternative ideas could be provided by students. This was proven by the answers of students in Table 2. CTS students who learned using IS learning experienced significant success. This can be seen with a variety of students who answered with a good conceptual ranging from a very less critical level to very critical because of the assistance of scaffolding. Several reasons can be found that scaffolding provides a path for students to solve problems faced (Haruehansawasin & Kiattikomol, 2017). Scaffolding can provide clearer direction that is clearer and does not confuse students 'thinking, because it helps students to easily understand the context of the problem while keeping students' focus on the basic concepts being studied. Also, it reduces the misconceptions that occur as a result of structured problem solving through more relevant basic concepts (Park, Tiwari, & Neumann, 2019).

CONCLUSION AND SUGGESTION

The results of the study concluded that the learning model with inquiry-based scaffolding techniques was superior in improving CTS and understanding the concepts, in students with high and low initial abilities. Therefore, this technique can be used in other learning by using different moderator variables. Thus, it can be recommended that IS learning can improve critical thinking skills and students' physics conceptual understanding.

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