Effectiveness of guided inquiry learning model to improve students' critical thinking skills at senior high school

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Abstract. This research aimed to describe the effectiveness of guided inquiry learning model to improve students' critical thinking skills. Subjects in the research were 90 students at three groups of senior high school grade X on Tarik (Indonesia), which follows a physics lesson on static fluid material in academic year 2016/2017. The research was used one group pre-test and post-test design. Before and after being given physics learning with guided discovery learning model, students in the three groups were given the same test (pre-test and post-test). The results of this research showed: 1) there is an increased score of students' critical thinking skills in each group on $\alpha = 5\%$; 2) average N-gain of students' critical thinking skills of each group is a high category; and 3) average N-gain of the three groups did not differ. The conclusion of this research is that learning model of guided inquiry effective to improve students' critical thinking skills.

1. Introduction
The era of globalization and the development of science and technology require a Human Resources (HR) quality. Education is essentially a conscious effort made to improve the skills of human resources in the 21st century challenges. Skills in the 21st century challenges by Trilling and Hood [1] includes: life skills and career skills, skills in technology, media and information as well as critical thinking skills and to innovate. These skills can be acquired through a learning process that is conducted both formal and non-formal. The focus of the 21st century learning process is not only aimed at the provision of material and concepts, but also on the development of students' skills in science learning [2].

According to Krulik and Rudnick [3] critical thinking is a way of thinking that test, connect, and evaluate all aspects of a problem situation, including the ability to gather information, memorize, analyze the situation, to read and understand and identify things required. Ennis [4] states there are six basic elements that need to be considered in critical thinking, namely: focus, rationale, conclusions, situations, clarity and overall examination. Facione and Facione [5] defines critical thinking as a make reflective decisions and resolve what is believed and done wisely. Halpern [6] argues that critical thinking is "cognitive skills and strategies that may enhance the desired result of thinking, i.e., purposeful, reasoned, and the actual destination - Miscellaneous think includes resolve the problem, formulate a conclusion, taking into account the possibility, and make a decision".

Critical thinking skills have to be applied in physics learning both in learning procedural knowledge so that the facts contained in each stage is easy to understand, as well as conceptual knowledge is more in need of the quality of higher thinking in order to connect these facts so that the concept was intended to be well [7]. Science education in the modern era focusing on the ability of students to be active in the
learning process through the exploration process. Specifically, the current education try to help students learn to organize and construct opinions, formulate problems, develop hypotheses, and look for evidence himself. Such processes can help students formulate their thinking abilities and manage their ability to solve problems that facilitate the learning of science concepts [8].

Preliminary study results show that the critical thinking skills of physics on the topic of Hooke's Law in Public Senior High School (SMAN)-1 Tarik (Indonesia) is still relatively low. 36.36% of students have not been able to formulate the problem correctly, 72.73% of students have not been able to provide arguments, 84.85% of students have not been able to do the induction, 66.67% of students have not been able to do evaluation, and 90.91% of the students have not been able to decide an action correctly.

Based on the results of the preliminary study, the problem arises how to improve students' critical thinking skills physics? One of the alternative solution according to Eggen [9] is to carry out learning inquiry model. Eggen believes that inquiry learning model can provide an opportunity and assist students in gaining an understanding of the scientific method to develop critical thinking skills, self-regulation, and an understanding of specific topics. This is supported by research results Jatmiko, Widodo, Martini, Budiyanto, Wicaksono & Pandiangan [10] which showed that the learning experience, experimentation, discussion sharing, and solving the problem is effective in increasing mastery of concepts, problem solving skills and decision-making. In addition, it is also supported by the results of research L.M. Sartorelli and R. Swartz [11] which concluded that by improving the analysis and develop the skills of observation / observed, the students' critical thinking skills can be improved. Likewise, the Nurs’ research [12] concluded that guided inquiry learning can train scientific thinking skills of students of grade X Natural Sciences (IPA)-4 SMAN-2 Malang, Indonesia on the topic of glasses and magnifying glass. Bilgin [13] states that guided inquiry as a student-centered approach has an influence on a student's academic success and develop scientific process skills of students. While Tyler [14] found that learning gives students the opportunity to acquire skills in problem solving will improve critical thinking skills.

Learning inquiry model is a learning model that based on constructivism. Constructivism is a point of view in learning that considered student must be active to build their own knowledge in order to understand theory and gain knowledge. Teacher isn’t take the role as person who transfer information but facilitation in learning which helped student to build their own knowledge. Madden [15] and Khulthau [16] said that the learning model of guided inquiry is a learning model that fulfill many curriculum requirements through engagement, motivation, and learning challenging in line with the purpose for the 21st century for educational institutions to guide students to think and learn through inquiry. Student obtain knowledge through exploration with their senses, including observe, listen, grope, feel and smell. Learning inquiry model invite student to explore their understanding through inquiry. Teachers’ role in learning inquiry model are determine kind of research that student doing and give guidance actively to student on collect the data, analysis, and make conclusion [17].

2. Method
This research is a pre-experimental design using one group pre-test and post-test, O1 X O2. O1 is the pre-test scores, X represents the physics lesson on the topic of static fluid guided inquiry model, and O2 is the post-test scores. Before the guided inquiry learning models performed, three groups of students grade X, namely: X IPA-1, X IPA-2, and X IPA-3 SMAN-1 Tarik (Indonesia) on Odd Semester Academic Year 2016/2017 given the critical thinking skills test (pre-test) on the subjects of physics on the topic of static fluid and after learning the three groups were also given the same test (post-test). The test of critical thinking skills consisted of 10 problems in essay (narrative form), with indicators, including: (1) the skills to formulate the problem, (2) give the argument, (3) induction, (4) evaluating, and (5) to decide a course of action [4]. Criteria scoring is done by using a scoring guidelines were adapted from Washington State University Critical Thinking Project [18].

Data in the form of students’ critical thinking skills that have been collected and analyzed using paired t-test, the calculation of the gain is normalized (N-gain), and analysis of variance (ANOVA). Paired t-test was used to analyze whether there is a difference between the scores of pre-test and post-test scores significantly on α = 5%; N-gain is used to determine the level increase in critical thinking
skills after learning static fluid model guided inquiry; and ANOVA were used to analyze the consistency of average N-gain. Critical thinking skills score is calculated using the formula:

\[
\text{Critical thinking skills} = \frac{\text{number of scores obtained}}{\text{number of total scores}} \times 100\%
\] (1)

Paired t-test and ANOVA was conducted after the assumption of normality and homogeneity of the sample met, while the N-gain is calculated using the formula Hake [19]:

\[
N - \text{gain} = \frac{S_{\text{post}} - S_{\text{pre}}}{S_{\text{max}} - S_{\text{pre}}}
\] (2)

with :
- N-gain = The normalized gain scores
- \(S_{\text{post}}\) = Post-test scores
- \(S_{\text{pre}}\) = Pre-test scores
- \(S_{\text{max}}\) = Maximum score

Furthermore, from the calculation of the N-gain is then converted to the criteria in Table 1.

| N-Gain       | Normalized Gain Criteria          |
|--------------|-----------------------------------|
| \(N-Gain > 0.70\) | High                             |
| \(0.30 \leq N-Gain \leq 0.70\) | Moderate                        |
| \(N-Gain < 0.30\) | Low                             |

**3. Result and Discussion**

**3.1. Result**

Data from the pre-test and post-test students' critical thinking skills for three groups of grade X: IPA-1, IPA-2, and IPA-3 are shown in Figure 1. While the average N-gain for the three groups of students grade X are shown in Table 2.

![Figure 1. Pre-test and Post-test Students Critical Thinking Skills](image)

Furthermore, based on the data score pre-test and post-test students' critical thinking skills and the fulfillment of the assumptions of normality and homogeneity of the sample, and then carried paired t-test and the results are shown in Table 3, Table 4 and Table 5.
### Table 2. The Average N-gain Three Groups of Students of Grade X

| No. | Grade | Average N-gain | Category |
|-----|-------|----------------|----------|
| 1.  | X IPA 1 | 0.72           | High     |
| 2.  | X IPA 2 | 0.74           | High     |
| 3.  | X IPA 3 | 0.71           | High     |
| Average |     | 0.72           | High     |

### Table 3. Paired t-Test Scores Pre-test and Post-test Students Grade X IPA-1

| Paired Differences | Mean  | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | t     | df  | Sig (2-tailed) |
|--------------------|-------|----------------|-----------------|-----------------------------------------|-------|-----|----------------|
| Pair 1             | -41.500 | 6.632          | 1.211           | Lower -43.976 -39.024 -34.274           | 29    |     | .000           |

### Table 4. Paired t-Test Scores Pre-test and Post-test Students Grade X IPA-2

| Paired Differences | Mean  | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | t     | df  | Sig (2-tailed) |
|--------------------|-------|----------------|-----------------|-----------------------------------------|-------|-----|----------------|
| Pair 1             | -42.867 | 7.229          | 1.320           | Lower -45.566 -40.167 -32.479           | 29    |     | .000           |

### Table 5. Paired t-Test Scores Pre-test and Post-test Students Grade X IPA-3

| Paired Differences | Mean  | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | T     | df  | Sig (2-tailed) |
|--------------------|-------|----------------|-----------------|-----------------------------------------|-------|-----|----------------|
| Pair 1             | -40.867 | 7.138          | 1.303           | Lower -43.532 -38.201 -31.360           | 29    |     | .000           |

### Table 6. Result of Uji One-Way ANOVA test for N-gain critical thinking skills of the students Grade X

| Sum of Squares | df  | Mean Square | F   | Sig. |
|----------------|-----|-------------|-----|------|
| Between Groups | .006 | 2           | .003 | .515 | .599 |
| Within Groups  | .474 | 87          | .005 |      |     |
| Total          | .480 | 89          |      |      |     |

Based on data from the value of average N-gain critical thinking skills in three groups of students grade X: IPA-1 IPA-2, and IPA-3 and the fulfillment of the assumptions of normality and homogeneity of the sample, then performed statistical tests One-Way ANOVA. Statistical Results of One-Way ANOVA test for average N-gain critical thinking skills of the students are shown in Table 6.

#### 3.2. Discussion

Based on Figure 1, before learning the fluid static guided inquiry model, the average score of critical thinking skills of students in each group in grades X: IPA-1 IPA-2, and IPA-3 shows a low value, less than 50 of scale range 0-100; These things happen perhaps because students have not been trained in
critical thinking skills by using guided inquiry learning model. Meanwhile, after learning the static fluid guided inquiry model, the average score of student thinking skills in three groups becomes high, the average score of each group of more than 80. This is possible because the students have gained a guided inquiry learning models. Table 2 shows that the average level of increase in student scores (N-gain) in the three groups each of more than 0.7 on the scale range 0-1, or a high category. This is probably because the students become accustomed to working critically and smoothly in: formulating the problem; arguing; induction; an evaluation; and decide a course of action. Table 3, Table 4, and Table 5 show that average of students’ critical thinking skills entire group grade X, including: IPA-1, IPA-2, and IPA-3, increasing significantly at $\alpha = 5\%$. This shows that the improvement of students' critical thinking skills scores in the three groups as do static fluid learning with guided inquiry model. Meanwhile Table 6 shows that the average level of increase in scores before and after the learning on three groups of students were not different (statistically), or it can be said that learning the fluid static model of guided inquiry gives the effect of increased scores critical thinking skills of students in the three groups with the level of improvement consistent.

An increase students' critical thinking skills score after the static fluid learning with guided inquiry model; with an average level of increase in high category and is not different for the three groups in accordance with the findings of Trundle [20], Brickman [21], Zawadski [22] and Minderhout & Loertscher [23], namely that students in early learning is not enjoying the guided inquiry-based learning as much activity they should do themselves although in conjunction with this, the skills students grow and be able to build his own knowledge. The application of guided inquiry learning not only improves students' ability to understand the material, but also can improve the skills of process and scientific work [24]; [25]; [26]; [27]. The stages in the inquiry learning model from stage to stage to formulate the problem deduce proven to assist students in making the concept of accommodation and assimilation as the theory of Piaget [28].

Social interaction within groups and among groups in inquiry learning model, according to Vygotsky can increase the level of potential development of students so that increased its closest development zone [29]. Active student involvement in inquiry-based learning can increase the storage of information in long-term memory, thus increasing mastery of concepts [28]. Results were also consistent with studies Kiumars, Ebrahim Mostafa Mohammad and Maboud [30] that there was a significant effect of guided inquiry method of learning to critical thinking skills and tentative conclusions. Nor was there any significant difference between men and women in the total value of critical thinking. Results of learning through inquiry model can improve the understanding of science, improve the learning objectives, the use of critical thinking [31], and improve the skills of predicting [32]. In addition, the results of this research also was supported by the results of research conducted by Prasetyowati and [33] which concluded that the inquiry model can improve the mastery of concepts and critical thinking skills of students, and there is a strong relationship and significant correlation between critical thinking skills to mastery of concepts students. Likewise, the results of research supported Jatmiko, Widodo, Martini, Budiyanto, Abrams, and Pandiangan [10] that the learning experience, the experiment is effective in increasing mastery of concepts, capabilities problems solving, and decision-making. This is consistent with the thinking Johnson and Siegel [34] that the thinking skills can help students to construct knowledge in the mastery of the whole concept.

4. Conclusion
Based on the research and the discussion concluded that the static fluid learning with guided inquiry model is effective in improving critical thinking skills of high school students grades X, as indicated by: (1) an increase in the average score of students' critical thinking skills before and after the learning significantly at $\alpha = 5\%$; (2) the increase in the average level of critical thinking skills, average N-gain high category; and (3) average N-gain is not different or consistent in the three groups of students.

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