Improving students’ analysis ability in science learning on simple machine topic using guided inquiry

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Abstract. Analysis ability is one of the important skills in higher-order thinking skills (HOTs). This study aimed to determine the effectiveness of guided inquiry model in improving students’ analysis ability on simple machine topic. This study was quasi-experimental study with pretest-posttest control-group design in one elementary school in Surakarta, Indonesia in 2017/2018 academic year with one class as an experimental class by using guided inquiry model and the other class as the existing class that used STAD (student teams achievement division) learning model. The data were obtained by using analysis ability test instrument in the form of multiple choices that has passed expert validations, namely the validation from the education and evaluation experts, science for elementary expert, and the certified elementary school teacher, as well as the empirical validation through try-out. The result showed that the average score of the analysis ability gain score calculation in the experimental class was higher by 0.66 compared to that in the existing class of 0.51. The independent sample t-test showed the difference between the experimental class and the existing class with the value of t of 3.554 and the sig value of 0.001 < 0.05, and the result of the effect size test was in large criterion. Based on the results of the study, it can be concluded that analysis ability in the aspects of organizing, differentiating, and distributing can be improved effectively through guided inquiry model activities.

1. Introduction
Science is one of the subjects in the elementary school curriculum containing knowledge that occurs in the natural environment around students [1,2]. The 21st century science learning should be carried out in scientific inquiry with a student-centred approach to foster creative thinking and critical thinking skills, be able to solve problems, train innovation skills and emphasize the importance of collaboration and communication [3]. Thinking skills developed should reach the Higher Order Thinking Skills, which are at the level of analysis, synthesis, evaluation and creation in the cognitive domain on Bloom's Taxonomy [4]. Science learning should be carried out in scientific inquiry to develop the ability to think, work, and be scientific and communicate it as an important aspect of life skills [5]. One aspect that needs to be considered by teachers in science learning is to provide opportunities for students to develop their thinking skills in explaining a problem [6,7]. Students' thinking ability develops when they discover facts, principles, theories, and concepts that they then apply to solve a problem [8,9]. The thinking ability that needs to be developed in science learning today is the ability to analyse [10,11]. The ability to analyse is a high-level thinking ability in the process of the cognitive domain of the revised Bloom's taxonomy [12,13]. Learning science at the elementary school level has not fully instilled and empowered the analysis ability or cognitive domain of the C4 level (analysis) [12,14].
Analysis is the ability to break down a material into simpler parts and determine the relationships between the parts and the overall structure or purpose [12,15]. Analytical thinking is the ability to identify and classify various aspects into small parts and find the relationship of the components to understand and see the relationship of the information provided [16,17]. This analysis ability directs students to be able to decipher information into small and simple parts and to be able to analyse the relationship of each part of that information [18,19]. The activity of comparing information in this analytical thinking ability is able to guide students to be able to generalize the information received into the form of conclusions [20,16]. The cognitive categories in the ability to analyse consist of 3, namely: organizing, distributing and differentiating [12]. In the differentiating category of the analysis ability, students are directed to sort out the relevant or important parts of a structure. The other similar terms of differentiating, among others, are setting aside, focusing, choosing, and sorting [12,21]. In the organizing category, students are directed to build the systematic and coherent relationship among the pieces of information. The organizing activities include finding coherence, dividing outlines, describing roles, integrating, and structuring [18]. In the category of distributing, students are able to determine the point of view, bias, and scores. They are able to determine the purpose of the author related to the information provided by the teacher [20,22].

Based on several studies that have been conducted, there is an influence of the Guided Inquiry learning model on the higher order thinking skills, responsibility for science materials and student activeness [23]. The study using the Student Teams Achievement Divisions (STAD) learning model turned out to have a positive influence on the students’ learning outcomes and activeness [24]. Based on the results of the study that has been done, this study focuses on finding out how the effect of the guided inquiry and STAD models on the students' ability to analyse in the simple machine topic. One effort to familiarize the students with the analysis ability is to use appropriate and innovative learning models [25,26]. The Guided Inquiry learning model consists of five stages of implementation, namely observation, manipulation, generalization, verification, and application [27]. The stages of the STAD learning model are classroom presentation, group work, quizzes, individual progress scores, group recognition (award) [28].

2. Method

2.1. Research design
This study was a quasi-experimental study with pretest-posttest control-group design [29]. The study was conducted by implementing guided inquiry learning model in the experimental class while in the existing class, the researcher applied STAD learning model commonly used by the teachers in the school. Both classes took pre-test first before receiving the treatment and post-test. The pretest-posttest results were scored according to the scoring rubric, and then analysed statistically. The data were analysed using SPSS 22.0 for Windows to find out the results of the descriptive pretest-posttest analysis, normality test with one sample Kolmogorov-Smirnov, homogeneity test with Levene’s Test, N-gain calculation [30], and Independent Sample t-Test while the effect size test was done with the interpretation [31].

2.2. Population and sample
The population in this study were the elementary school students in Surakarta. The samples used in this study were the fifth-grade students in the odd semester of 2017/2018 academic year with 62 students. The sampling was done purposively in an elementary school based on the data of the national examination analysis and the results of the initial profile test of the analysis ability. A total of 31 students were in the experimental class using the guided inquiry model while 31 students were in the control class using the learning model used by the teachers at the school.
2.3. Research instruments

The data were obtained using the test instrument to measure analytical skills. The instrument in the form of multiple-choice questions consisting of 40 items with 4 answer choices (score 1 for the correct answer). Each question was arranged based on three indicators of analytical skills including organizing (13 items), differentiating (13 items), and distributing (14 items) that have passed validation [10]. The instrument validation was carried out by 4 experts consisting of 2 education and evaluation expert lecturers and 2 certified elementary school teachers using V. Aiken's analysis [32]. All the test items were valid with the V. Aiken index value ranging from 0.607 to 0.643. Empirical validation was done through the experimental test showing that the instrument was valid and reliable. The instrument validity test was conducted using the Pearson Product correlation test. The instrument validity test was conducted using Pearson’s Product Moment correlation test with the following requirements: if $r > r_{table}$, the item is considered as valid; and if $r < r_{table}$, the item is considered as invalid and is removed. The instrument of the validity test obtained the lowest score of 0.515 and highest one of 0.892 $> r_{table}$, with 20 students as the respondents with $r = 0.443$, meaning that the instrument of critical thinking skill item is valid. On the other hand, the reliability test obtained from Alpha Cronbach is 0.941 $> 0.443$ meaning that each of the items is reliable to be implemented in the experimental and existing classes. Each model of learning was implemented in the 4 meetings with 2 hours x 35 minutes in different classes each. In each meeting, the different simple machine material was taught. The first meeting was about the concept of pulleys. The second meeting was about the concept of inclines. The third meeting was about the concept of wheels and the fourth meeting was about the concept of pulleys.

3. Results and discussion

3.1. The gain-score analysis results of pre-test and post-test scores of the analysis ability

The analysis ability pre-test and post-test scores were then calculated to determine the level of improvement of the results of the guided inquiry model on the topic of simple machine. A summary of the results of the average Profit Score analysis on the results of the analysis ability test is presented in Table 1 below.

| Classes          | Mean of gain score | Criteria |
|------------------|--------------------|----------|
| Experimental class | 0.65               | Medium   |
| Existing Class   | 0.50               | Medium   |

Table 1 indicates that the average gain score of the class using guided inquiry shows a result of 0.65. In the existing class, the result is 0.50 in the medium category [30]. The average score of the calculation of the acquisition score of the experimental class is higher than that of the existing class.

3.2. The analysis results of independent sample t-test

An independent sample t-test was conducted to determine whether there was a difference between the N-gain score of the analysis ability in the experimental class and the existing class. The prerequisite tests in the form of normality and homogeneity tests carried out before the t-test showed that the average gain score of the pre-test and post-test of the analysis ability of the experimental and existing classes was normally distributed, but not homogeneous. Therefore, further testing using an independent sample t-test was carried out by reading the calculation results in the same assumed column of variance. The results of the independent sample t-test can be seen in Table 2 below.

| Data               | t-Test for the equality of means | df  | Sig. (2-tailed) |
|--------------------|----------------------------------|-----|----------------|
| N-gain             | Equal variances not assumed      | 3.554 | 54.923 | 0.001 |
The results of the independent sample t-test show that the sig value of (2 tailed) is 0.001 < 0.05, then H0 is rejected and Ha is accepted. Thus, there is a difference of the average N-gain score between the experimental and existing classes. This difference shows that the guided inquiry model applied to the experimental class was effective in improving the students’ analysis ability. The level of effectiveness of the model in enhancing the analysis ability can be known by further testing after an independent t-sample test and effect size test.

3.3. The analysis results of the effect size test
The results of the effect size test analysis using Cohen's test for independent sample t-test with Rstat Effect Size Calculator for t-Test on N-gain scores are shown in Table 3 below. The results of the effect size test showed that the use of the learning model has a large effect on the improvement of the analysis ability shown by the results of the effect size test based on Cohen's formula d of 0.88 [31].

| Classes   | Mean | Std  | Cohen’s d | Interpretation |
|-----------|------|------|-----------|----------------|
| Experiment | 0.66 | 0.12 | 0.88      | Large          |
| Existing  | 0.51 | 0.19 |           |                |

Based on the results of the N-Gain Score and Effect Size, the analysis ability of the students in the experimental class using Guided Inquiry was higher than that in the existing class using the STAD model, which was caused by several factors. The Guided Inquiry learning model that has been applied in simple machine learning can guide and train the students to find out a concept for the problems obtained from the results of student observations through experimental activities by themselves. This is in accordance with the results of the study [23]. Through the application of the Guided Inquiry learning model, the students can learn through experience and knowledge that they already have. It encourage active learning and develop the ability to think through the guidance given by the teacher during the learning process in accordance with the cognitive learning theory [33]. In the application of the Guided Inquiry model that has been carried out, the role of the teacher is inquiry-oriented that is to create an environment for the students to stimulate questions and create problems. Through the problems given by the teacher, it can stimulate the students to find out and try to prove the answers to the problems that have been given by the teacher through experimental activities. This is in line with the theory of information processing [34]. The experimental activities that have been carried out provide a description of the concepts found and used as a basis for the students to be able to answer similar problems given by the teacher. The benefit of the Guided Inquiry learning model based on the results of this study is to provide meaningful learning experiences to the students and train them to independently solve problems through their learning experiences in accordance with the study [35]. The novelty of the application of the inquiry learning model in this study is training the students to be able to think creatively about the problems faced. Creative thinking is a way of thinking that is expected in 21st century education and is covered by Bloom's revised taxonomy level, one of which is the analytical ability. The low influence of the implementation of the STAD learning model on the simple machine topic is because STAD is part of cooperative learning so that it emphasizes the collaboration through group activities that require special skills from the students including collaboration, competitiveness and communication in accordance with the results of the study [28]. The STAD learning model is more suitable to be used with the aim of increasing collaboration [28], the students’ ability to compete and communicate. Hence, the STAD learning model on the simple machine topic that has been implemented has not been able to facilitate and have a major influence on students' ability to analyse.

4. Conclusion
Based on the results of this study, it can be concluded that inquiry guided model applied to the simple machine topic can improve the students' analysis ability. The effectiveness of the guided inquiry model
can be seen from the independent sample t-test showing that there is a difference between the experimental and the existing classes with the t of 3.554 in the sig value 0.001 < 0.05, and the effect size test result is in the large criterion. The result from the average score significance of the analysis ability gain score calculation in the experimental class is higher by 0.66 compared to that in the existing class of 0.51 in the medium criterion. This gain score increase occurs in every aspect of the students' analysis ability in the medium criterion. Therefore, the analysis ability in every aspect of differentiating, organizing, and attributing can be effectively enhanced through the activities of the guided inquiry model.

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