Comparison of guided discovery assisted by calculators and scientific approaches in terms of students' higher-order thinking skills in mathematics

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**Abstract**. In learning mathematics in schools, the right strategy is needed, namely by applying various kinds of learning models. The use of the right learning model can encourage the growth of pleasure in the learning process, foster and increase motivation in doing assignments, and make it easy for students to understand lessons that are considered difficult. This study aims to describe: (1) the effectiveness of calculator-assisted guided discovery learning in terms of higher order thinking skills (HOTS), (2) the effectiveness of learning the scientific approach in terms of HOTS, (3) more effective learning between calculator-assisted guided discovery and approaching scientific in terms of HOTS. This research is a quasi-experimental research with the pretest-posttest two treatment design. The population in this study were all students of class X in a public high school in Karawang, West Java. The research sample was selected 2 classes from 6 existing Mathematics and Natural Sciences group classes. The instrument used to collect data was the HOTS test. The results showed that: (1) calculator-assisted discovery learning was effective against HOTS, (2) scientific approach learning was effective against HOTS, (3) calculator-assisted guided discovery learning was more effective than scientific approach learning in terms of HOTS.

1. Introduction

Various approaches, strategies, and learning models are developed for experts to improve students' mathematical abilities. Approaches, strategies, or learning models that are expected to be useful for efforts to improve the mathematics learning process to improve students' mathematical abilities. No approach, strategy, or learning model is suitable for fixing all problems in the learning process and applies to all students in a class. Therefore, the use of approaches, strategies, or learning models must be heterogeneous so that all kinds of needs and problems can be met and minimized.

Accuracy in using approaches, strategies, or learning models will at least be able to provide opportunities for students to practice their abilities so that they can achieve the standard of students' ability to achieve learning. The learning principle desired by the 2013 curriculum in use today is that teachers must facilitate students to develop their skills and abilities in finding and connecting concepts known as student-centered learning approaches [1]. Some alternative learning models that can be used are guided discovery learning models, learning with the use of technology, and learning scientific approaches.

Various choices of learning models can of course also be implemented for the mathematics learning process. Mathematics is one that is important to learn for students. At every level of education, from elementary school to college, it is inseparable from mathematics. In everyday life, mathematics plays an important role because mathematics is not only applied when learning mathematics itself but mathematics is also applied to other fields of science [2]. The Indonesian government, especially the Ministry of National Education, has made efforts to improve the quality of mathematics education, both through improving the quality of mathematics teachers through upgrades, as well as increasing student achievement through increasing the minimum standard of National Exam scores for graduation in mathematics subjects [3].

Learning outcomes can be in the form of cognitive aspects, such as higher order thinking skills. Higher order thinking skills will make students have the ability to face problems that are more complex than ordinary problems [3]. Higher order thinking skills can improve student achievement. The use of assignments and assessments that require intellectual and critical thinking has a relationship with increased student achievement [4]. This increase is indicated by various kinds of achievement results such as test results and so on.

The higher the level of education, the higher the complexity of a mathematical material [5]. This of course requires good thinking skills, one of which is trained through higher-order thinking skills that are accustomed to the learning process. So the question is how to create effective mathematics learning that is oriented towards increasing student HOTS? HOTS is also a skill that is needed in mathematics learning. This is also supported by research which states that in learning mathematics, HOTS is important [5]. This is because HOTS develops students' ability to analyze, evaluate, and create, so that students will have the ability to think critically and think creatively in solving problems in their daily lives [6]. HOTS deals with thinking skills that can be done by individuals [7].

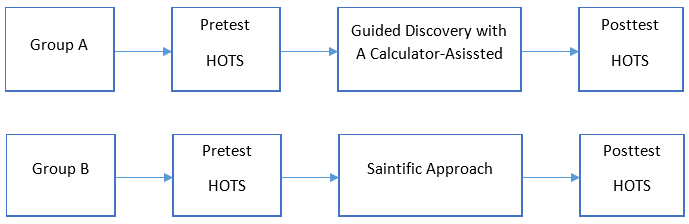
HOTS occurs when someone gets new information, holds it, organizes, and associates it with existing knowledge and then passes the information on to achieve a specific object or solution to a problem [8]. This is supported by Yen et al, who said that thinking skills that can be categorized in HOTS are critical thinking skills, creative thinking, problem-solving, conclusion, and metacognitive [9]. The same thing was expressed by Conklin who said that HOTS characteristics include the ability to think critically and creatively [7]. Thus, it can be concluded that thinking skills categorized as HOTS are critical thinking and creative thinking.

The use of technology is very important for learning mathematics because it can improve student learning outcomes. One of the uses of technology that can be used in learning to improve higher-order thinking skills is a calculator. However, the use of calculators in mathematics learning has mixed opinions. People generally see the calculator as a tool for calculation and mathematics teachers often disagree with using it [10]. Many teachers have rejected the use of technology, especially calculators in their instructional activities because they think technology will interfere with their role as teachers [11]. In addition, many teachers worry that using calculators will hinder students' conceptual understanding. The use of calculators is more effective and can test ideas or strategies that students have.

Long-term use of calculators does not necessarily improve or hinder student achievement [12]. Yet another study found a significant advantage of students using calculators over those not [10]. With the use of calculators, teachers can present mathematical concepts (representational functions)[13]. The use of learning activities with a calculator is able to guide students in finding mathematical concepts (exploration function). By using a calculator, students can calculate complex number questions (compensation function), even students can use it to check answers (affirmation function). Various calculator functions can be elaborated on in learning mathematics. Although it has many functions that can be utilized, not all teachers have used calculators in mathematics learning [13]. Whereas according to research there is an influence on students' mathematics learning achievement with the integration of Classwiz's scientific calculator in mathematics class [14]. Therefore, this study describes the effectiveness of guided discovery learning assisted by calculators in terms of higher order thinking skills (HOTS), the effectiveness of learning scientific approaches in terms of HOTS, and more effective learning between guided discovery assisted by calculators and scientific approaches in terms of HOTS.

1. Methods

Penelitian ini adalah penelitian eksperimen semu. Desain dalam penelitian ini adalah the pretest-posttest two treatment design [15]. Kelompok eksperimen terdiri atas dua kelompok dalam satu sekolah, yaitu kelompok penemuan terbimbing berbantuan kalkulator dan kelompok pendekatan saintifik. Secara skematis desain eksperimen yang digunakan dalam penelitian ini seperti pada Gambar 1.

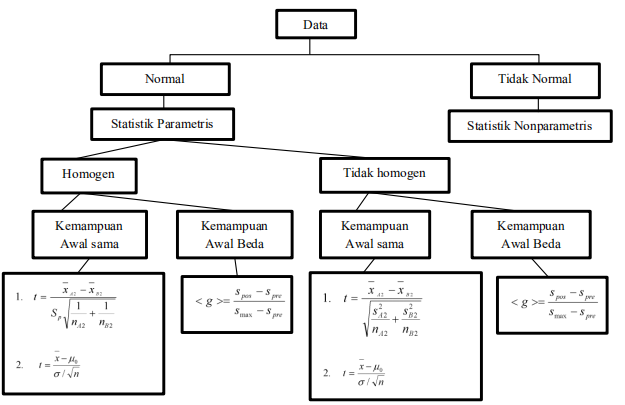


Gambar 1. Desain Eksperimen

The research site is a public high school in Karawang in class X of the MIPA program. This research was conducted in the even semester of the 2019/2020 academic year online due to the COVID-19 pandemic. Then from the two classes are randomly selected to determine the type of learning to be used. The variables in this study consisted of the dependent variable and two independent variables. The dependent variable in this study is HOTS. The independent variables of this study are guided discovery assisted by calculators and scientific approaches.

The data collection techniques used in this study were: (1) giving a pretest (higher-order thinking ability test) accompanied by a mathematics subject teacher before treatment, (2) giving a posttest (higher order thinking skills) accompanied by a mathematics subject teacher after treatment. The instrument used in this study was a test instrument in the form of an open problem to measure HOTS. The test instrument is validated by using expert judgment techniques, namely asking for expert judgment related to content validation. The experts who validated the test instruments were 2 mathematics education experts. After the instrument was corrected by the validator, the instrument was then revised based on the input given by the validator.

The data analysis technique used includes descriptive analysis which is used to describe the characteristics of the research data and to answer descriptive problems. This analysis is used for data in the form of the maximum score, minimum score, mean, standard deviation, variance, and percentage. Data on students' higher order thinking skills used multiple-choice tests and essays. The results obtained are converted into values ​​ranging from 0 to 100. The scores are then classified into criteria based on the minimum completeness criteria (KKM) set by the school for mathematics, namely 75. The following is the flow of inferential statistical analysis techniques in this study.



Gambar 2. Alur Penelitian

The data used in statistical analysis are pretest and posttest data. Statistical analysis used one sample t-test and independent sample t-test with the help of SPSS 21 for windows. Test one sample t-test and independent samples t-test to determine the effectiveness of guided discovery learning assisted by calculators in learning mathematics to higher order thinking skills (HOTS), the effectiveness of learning scientific approaches in learning mathematics to higher order thinking skills (HOTS), and comparison the effectiveness of guided discovery learning assisted by a calculator with a scientific approach in learning mathematics towards higher order thinking skills (HOTS). The decision criteria are taken if the Sig. at the SPSS output less than α = 0.05, then H0 is rejected.

**3. Result and Discussion**

The data collected during the study consisted of HOTS pretest and posttest scores as quantitative data. The data is then compiled according to the scoring guidelines, namely the highest score of 100 and the lowest score of 0. The data analyzed to show the results of the trial are data obtained before (pretest) and after treatment (posttest), both the guided discovery learning group assisted by a calculator and the scientific approach group. The data in question is the HOTS test result data. In summary, the HOTS pretest and posttest results can be seen in Table 1.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Statistic Score | Guided Discovery with A Calculator-Asissted Learning | | Saintific Approach Learning | |
| Pretest | Posttest | Pretest | Posttest |
| Jumlah siswa (n) | 36 | 36 | 36 | 36 |
| Skor Maksimum | 100 | 100 | 100 | 100 |
| Skor Minimum | 0 | 0 | 0 | 0 |
| Skor Tertinggi | 80 | 90 | 75 | 85 |
| Skor Terendah | 35 | 70 | 40 | 55 |
| Skor Rata-Rata | 58.19 | 81.94 | 58.33 | 80.69 |
| Variansi | 128.79 | 21.83 | 90.00 | 40.22 |
| Simpangan Baku | 11.35 | 4.67 | 9.49 | 6.34 |

Tabel 1. Deskripsi Data *Pretest* dan *Posttest* pada Kelas Penelitian

Next will explain the data analysis before treatment in this study. Before the hypothesis testing is carried out on the data that has been obtained, first the assumption test is carried out. The results shown were the output of the Kolmogorov-Smirnov test using SPSS 21 software at the HOTS pretest and posttest for the calculator-assisted guided discovery group and the scientific approach group. When viewed from the results of the significant test, it can be seen that if the probability value is more than 0.05, all of the data obtained is normally distributed. Thus the data normality assumption is fulfilled. It can be concluded that the data were taken from a normally distributed population, as shown in Table 2.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Kelas** | **Tes** | **Asymp. Sig** | **Α** | **Putusan** | **Simpulan** |
| Guided Discovery with A Calculator-Asissted Learning | Pretest | 0.024 | 0.01 | H0 diterima | Data Berdistribusi Normal |
| Posttest | 0.151 | 0.01 | H0 diterima | Data Berdistribusi Normal |
| Saintific Approach Learning | Pretest | 0.246 | 0.01 | H0 diterima | Data Berdistribusi Normal |
| Posttest | 0.058 | 0.01 | H0 diterima | Data Berdistribusi Normal |

Tabel 2. Hasil Uji Normalitas

After that, the homogeneity test of variance was carried out to determine whether the higher order thinking skills (HOTS) data had the same variance or not. The homogeneity test of variance was carried out by the independent t-test assisted by SPSS 21 using the One Way ANOVA test, the following results were obtained.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tes** | **Asymp. Sig** | **α** | **Putusan** | **Simpulan** |
| Pretest | 0.021 | 0.05 | H0 diterma | Ragam Homogen |
| Posttest | 0.987 | 0.05 | H0 diterma | Ragam Homogen |

Tabel 3. Hasil Uji Homogenitas Ragam

Based on table 3, it can be seen that the pretest value data in the guided discovery class assisted by calculators and the scientific approach have different varieties. And the posttest value data in the guided discovery class assisted by calculators and the scientific approach have the same variety. After the normality test and the homogeneity test of variance, the hypothesis testing is continued to answer the problem formulation, first testing whether the guided discovery class assisted by a calculator and the scientific approach have the same abilities. The initial average similarity test was carried out by the independent t-test assisted by SPSS 21, the results were as follows.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Asumsi** | **Tes** | **Nilai Sig.** | **α** | **Putusan** | **Simpulan** |
| Ragam Homogen | Pretest | 0.998 | 0.05 | H0 ditolak | Terdapat kesamaan rata-rata kemampuan awal. |
| Ragam Homogen | Posttest | 0.322 | 0.05 | H0 ditolak | Terdapat kesamaan rata-rata kemampuan akhir. |

Tabel 4. Hasil uji kesamaan rata-rata untuk pretest dan posttest.

From table 4 it can be concluded that the guided discovery class assisted by a calculator and the scientific approach have the same initial abilities. The next analysis is hypothesis testing on the posttest value of reasoning ability. Hypothesis testing to answer the problem formulation uses the help of SPSS 16. Learning is said to be effective against higher order thinking skills (HOTS) if the average student achieves a posttest score of more than 75.

Data analysis after the effectiveness test treatment was carried out to determine whether or not the guided discovery was effective in cooperative learning, the guided discovery type was assisted by a calculator and the guided discovery approach in cooperative learning was the scientific approach type in terms of student HOTS. This effectiveness test was carried out with the help of SPSS 21 using the one sample t-test with a significance level of α = 0.05. The first hypothesis test was conducted to determine the effectiveness of guided discovery learning assisted by calculators in mathematics learning towards higher order thinking skills (HOTS). The hypothesis will be tested using the one sample t-test with the help of SPSS 21 for the significance level. The following results were obtained.

|  |  |  |  |
| --- | --- | --- | --- |
| **Nilai Sig.** | **α** | **Putusan** | **Simpulan** |
| 0.000 | 0.05 | H0 ditolak | Pembelajaran penemuan terbimbing berbantuan kalkulator efektif. |

Tabel 5. Hasil uji hipotesis pertama

Based on table 5, it can be seen that the experimental class treated with guided discovery learning assisted by a calculator is effective against higher order thinking skills (HOTS). Furthermore, the second hypothesis test was carried out to determine the effectiveness of the scientific approach to learning mathematics towards higher order thinking skills (HOTS). The hypothesis will be tested using the one sample t-test with the help of SPSS 21 for the level of significance. The following results were obtained.

|  |  |  |  |
| --- | --- | --- | --- |
| **Nilai Sig.** | **Α** | **Putusan** | **Simpulan** |
| 0.000 | 0.05 | H0 ditolak | Pembelajaran pendekatan saintifik efektif. |

Tabel 6. Hasil uji hipotesis kedua

Based on table 6, it can be seen that the class given the scientific approach is effective against higher order thinking skills (HOTS). The test value for HOTS is 75 according to the completeness criteria of learning mathematics in the school where this research was conducted. The results of these 2 tests indicate that between the guided discovery group assisted by a calculator and the scientific approach in terms of HOTS, each has a significance of 0.000 <0.05. So it can be concluded that the type of guided discovery learning assisted by a calculator and the type of scientific approach is effective in terms of HOTS.

This is in line with the theoretical study which reveals that guided discovery learning is effective in terms of student HOTS. Learning discovery that is guided by the teacher (guided discovery) helps students work more directed in an effort to achieve predetermined goals. This learning can be held individually or in groups. The teacher guides students if necessary and students are encouraged to think for themselves so that they can find general principles based on the material provided by the teacher.

Calculators can potentially shift the paradigm of learning activities from concentrating on manipulative skills to developing concepts, relationships, and problem solving skills. Calculators can be used to achieve many math learning objectives. Calculators with appropriate usage strategies can improve student understanding, solve problems, explore concepts and connections through multiple representations, and even develop student understanding. The use of calculators in the upper middle class makes it possible to concentrate more on thinking about problems that require understanding concepts and creative approaches, but this success depends largely on how to use calculators in the classroom and the instructions given by the teacher. Therefore, the combination of guided discovery and the use of calculators must be involved in learning mathematics because it can condition students to explore, observe, study, and make conjectures without doubting their ability to calculate. Students who have explored and made conjectures in thinking can be categorized as having good high-order thinking skills (HOTS) [16].

Meanwhile, the scientific approach has the advantage of encouraging and inspiring students to think critically, thus inspiring students to be able to think hypothetically to see differences, similarities and interrelationships with each other on the substance of learning. This includes higher order thinking skills. HOTS occurs when someone gets new information, holds it, organizes and associates it with existing knowledge and then passes that information on to achieve a specific object or solution to a problem [8].

Because the two learning models are effective against HOTS in mathematics learning, further analysis is needed to test the comparison of the two in terms of student HOTS using the univariate test. The difference in the effectiveness of the calculator-assisted guided discovery learning compared to the scientific approach in learning mathematics towards higher order thinking skills (HOTS). The univariate test is intended to see which learning approach is more effective. The univariate test was carried out on the data obtained after treatment. The univariate test is done by calculating the t value on the univariate test (independent sample t-test). This test uses the help of SPSS 21. In detail, the results of the independent sample t-test are in Table 7.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Asumsi** | **Nilai Sig.** | **α** | **Putusan** | **Simpulan** |
| Ragam Homogen | 0.000 | 0.05 | H0 ditolak | Pembelajaran penemuan terbimbing berbantuan kalkulator lebih efektif dibandingkan pendekatan saintifik |

Tabel 7. Hasil uji hipotesis ketiga

Based on table 7, it can be seen that the results of the data presented are that the class treated with guided discovery learning assisted by a calculator is more effective than the class treated with the effective scientific approach to higher order thinking skills (HOTS).

**4. Conclusion**

Based on the information obtained in the study, it can be concluded that (1) guided discovery learning assisted by calculators is effective against HOTS, (2) scientific approach learning is effective against HOTS, and (3) guided discovery learning assisted by calculators is more effective than scientific approach learning in terms of HOTS. For teachers, students who excel should be empowered by guiding these students to become peer tutors for their other friends. Apart from increasing the abilities of these students as well as for other students. For other researchers, it is hoped that if they want to do similar research, it is better if they have other competencies in students' higher order thinking abilities.

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