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A META-ANALYSIS OF THE EFFECT OF DISCOVERY LEARNING MODEL ON STUDENTS' CONCEPTUAL UNDERSTANDING AND MATHEMATICAL REASONING ABILITIES

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ABSTRACT

The existence of inconsistencies in the results of primary research on the effectiveness of the Discovery Learning model on students' ability to understand concepts and mathematical reasoning encouraged researchers to conduct research that aims to examine the differences in the effect of the discovery learning model on students' ability to understand concepts and mathematical reasoning as a whole as well as in terms of educational level, sample size, and research demographics. This test was conducted using a Systematic Literature Review (SLR) with a meta-analysis method to obtain more comprehensive conclusions. Through testing on 41 primary studies, it was found that the implementation of the Discovery Learning model had a significant effect on the mathematical concepts understanding abilities as a whole. The study characteristics of the educational levels and research demographics lead to differences in the effect of the students' mathematical concept understanding abilities, with the highest effect at the junior high school education level and the demography of the research islands of Bali and Nusa Tenggara. However, the study characteristics of the sample size did not show any differences in the effect. In addition, it was also found that the implementation of the Discovery Learning model had a significant effect on the mathematical reasoning abilities as a whole after testing 45 primary studies. The study characteristics of the sample size led to differences in the effect of the students' mathematical reasoning abilities, with the highest effect on a sample size of less than 30 students. However, the study characteristics of educational levels and research demographics did not show any differences in the effect. Thus, the results of this study imply that educators can implement the Discovery Learning model as an effort to improve students' mathematical conceptual understanding and reasoning abilities.

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1. INTRODUCTION

Mathematics is a compulsory science in the Indonesian national education curriculum. Students are required to have basic competencies following the following objectives of learning mathematics, including understanding concepts, problem solving, reasoning, communication, and critical thinking (JDIH, 2022). In line with that, the National Council of Teachers of Mathematics (NCTM, 2000) explained that there are five standards in mathematics education goals: process standards and content standards. The process standards for the goals of mathematics education are problem-solving skills, reasoning and proof, communication, connection, and representation. These abilities will be valuable assets for students in the future.

The ability to understand concepts is one of the important abilities listed in the goals of learning mathematics. Mathematics, which contains previously unknown symbols or terms, requires students to understand mathematical concepts before manipulating these symbols. Knowing these mathematical concepts, it can be seen to what extent students have understood the language of mathematics in each process of learning mathematics (Mercy et al., 2015). By understanding the concept, students will better understand what they learn and do. Thus, their knowledge is not just memorizing or remembering. The ability to understand mathematical concepts also influences the results of learning mathematics (Novitasari & Leonard, 2017). Without understanding the concept, it is difficult for students to achieve the predetermined learning competencies.

Higher-order thinking abilities, suppose as reasoning ability, are also influenced by the ability to understand concepts. Students can think and reason about a mathematical problem if they understand mathematical concepts well to solve existing problems (Fuadi et al., 2016; Munasiah et al., 2020). Discussing reasoning ability, this ability is also one of the objectives of learning mathematics. In the opinion of Sugianto et al. (2014), the foundation of mathematics is reasoning. Mathematics and reasoning are two related contexts, where reasoning can be trained through mathematics learning activities. On the other hand, mathematical material is understood through reasoning (Ibrahim & Suparni, 2012). Mathematical reasoning ability is the ability to draw conclusions or make new logical decisions that can be explained or proven correct based on an understanding of concepts previously obtained (Khairunnisa & Amry, 2021).

Given the importance of the ability to understand concepts and mathematical reasoning, it is expected that every student can have this ability in themselves. These abilities can be improved by encouraging learning activities, such as the Discovery Learning model. The Discovery Learning model provides opportunities for students to develop and find their understanding so that the material taught is easily absorbed and stored properly by their memory system. It also provides opportunities for students to play more active roles in class (H. Ahmad, 2015). With this learning, students can become problem solvers, scientists, or mathematicians who carry out activities to collect information, analyse, compare, organise, integrate, and make conclusions.

This discovery learning has been widely researched regarding its effect on students' mathematical abilities. Some of these studies explain that guided discovery learning significantly affects the ability to understand students' mathematical concepts, one of which is research by Silviana and Novitasari (2018). It was also obtained that learning using the discovery model was better than conventional learning (Harisuddin, 2020; Laili et al., 2019; Putro et al., 2019). Furthermore, research by Lestari and Ristontowi (2021) concluded that learning using the Discovery Learning model is better than the AIR and conventional models. These studies describe the effectiveness of discovery learning on the ability to understand mathematical concepts.

There is not only research into the effect of the Discovery Learning model on the ability to understand mathematical concepts, but also those who look at its effect on mathematical reasoning abilities. As the research of Asmianti and Agustyarini (2021) concluded that the application of guided discovery learning has an effect on students' mathematical reasoning abilities. In addition, several studies also state that guided discovery learning is more effective than ordinary learning in increasing mathematical reasoning abilities (Hadi, 2016; Hermawan & Hidayat, 2018; Pahmi, 2020). Simanjuntak (2017) in his research, found that students' reasoning abilities using the discovery learning model were better than the wingeom-assisted problem-based learning model. Based on this research, it was found that the discovery learning model affected students' mathematical reasoning abilities.

However, several studies have the opposite effect on the ability to understand concepts and mathematical reasoning using the discovery learning model. Khofifah et al. (2021) and Septia et al. (2018), who obtained the discovery learning model, had not reached the effective proportion of the ability to understand the expected mathematical concepts. Then, Rahman and Maya (2017), Rolina et al. (2018), and Saputra et al. (2016) concluded that students' mathematical reasoning abilities through discovery learning were not better than other models. The results of these studies show inconsistent influence on the effectiveness of the discovery learning model on students' mathematical reasoning and conceptual understanding abilities. The intervention of the influence of several study characteristics can cause the inconsistency of the findings from one another.

Lipsey and Wilson (2001) state that several potential factors, such as educational level, sample size, research demographics, etc, can cause the diversity of study results. Academic level is one of the factors because it relates to the condition of students' cognitive development. Furthermore, the sample size refers to implementing education policies in Indonesia regarding the number of students per class. Classes with fewer than 30 students and more than 30 may provide different conduciveness. Then, for research demographic reasons, students' ability in each region may vary due to differences in community culture. Factors that have the potential to cause this heterogeneity need to be investigated further to provide clear and precise information.

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The inconsistency of research results presented by primary studies raises doubts about the effectiveness of the discovery learning model on students' mathematical reasoning and conceptual understanding abilities. Thus, it is necessary to carry out a more in-depth study with the Systematic Literature Review (SLR) using the meta-analysis method. Meta-analysis is a method or technique of quantitative analysis aimed at re-analyzing research results that are processed statistically based on primary data collection to organize and extract as much information as possible from the data obtained (Bloom et al., 2009; Glass, 1976; Hunter & Schmidt, 2004). Various study findings that initially seemed contradictory and difficult to accumulate eventually became more integrative and systematic through meta-analysis (Juandi & Tamur, 2021). Meta-analysis uses statistical processing to test hypotheses whose results are in the form of an effect size so that the objectivity is more accurate and guaranteed.

There is also no meta-analysis study related to the discovery learning model that links students' mathematical reasoning and conceptual understanding abilities. Thus, it becomes something new for researchers to study this case. Several meta-analysis studies related to the discovery learning model for other mathematical skills have been conducted by several researchers. Kholili et al. (2021) regarding the Discovery Learning (DL) model on students' creative thinking abilities. Their research used 9 primary studies and concluded that students' creative thinking abilities were more effectively used in the discovery learning model with a scientific approach at the junior high school education level, with geometric material regarding geometric shapes, with an overall effect size value of 1.23 in the strong category.

Furthermore, Nugroho et al. (2020) conducted research regarding the meta-analysis of the influence of discovery-based models and the environment on mathematical problem-solving abilities. It is concluded that the ability to solve mathematical problems using an environment-based model is better than using an invention-based model. This is shown from the effect size value in each model, where the environment-based model has an effect size of 1.245. Meanwhile, discovery-based learning only has an effect size of 0.762. Other research was also conducted by Karlina & Anugraheni (2021), who conducted a meta-analysis on improving mathematics learning outcomes in elementary students using the discovery learning model. In addition, some studies examine elementary students' mathematical critical thinking skills (Eskris, 2021; Mahmudah, 2021). These studies are a series of previous studies.

Based on the problems described above, this study aims to examine the differences in the effect of the discovery learning model on students' overall conceptual understanding and mathematical reasoning abilities, as well as in terms of educational level, sample size, and research demographics from the analysed primary studies.

2. METHOD

This research was conducted by analyzing statistical data from a number of primary studies to obtain differences in the effect of the discovery learning model on the ability to understand concepts and mathematical reasoning as a whole, as well as in terms of several study characteristics. The characteristics of the studies used as observers in this study were educational level, sample size, and research demographics. To achieve this goal, a comprehensive analysis of the findings of the primary research was carried out using a method called meta-analysis. The meta-analysis method is a systematic review that uses formal statistical analysis (Nindrea, 2016). This results in more robust inference estimates than conventional hypothesis testing. Thus, the conclusions reached are more comprehensive than those reported by individual studies.

Inclusion criteria

Inclusion criteria were used to limit the primary studies to be used. Domain inclusion criteria in this study used the Population, Interventions, Comparator, Outcomes, and Study Design (PICOS) framework.

1) The specified population is students at the education level of primary school, junior high school, and senior high school.
2) The primary study interventions studied are implementing the Discovery Learning model and the like as an experimental class.
3) The comparison used in the primary study is the implementation of models other than Discovery Learning (such as conventional, contextual, PBL, etc.) as the control class.
4) The outcomes used are students' ability to understand mathematical concepts or mathematical reasoning abilities.
5) Study design, namely, quantitative research with experimental and quasi-experimental methods.

Apart from using the PICOS framework, another limitation of this research is that the primary studies published over the last 10 years (2012-2022) were published in journals, proceedings, theses, and dissertations. The primary research provides some complete statistical information, which includes the mean, standard deviation, sample size, t-value, and p-value in the experimental class (discovery learning) and the control class (other than discovery learning). Besides that, it presents other information such as the level of student education, sample size, and research demographics.

Data collection technique

Data collection techniques in this meta-analysis research use electronic search engines such as Google Chrome and the Publish or Perish 8 application using search strings which are carried out using the keywords: "discovery learning", “concept understanding”, “reasoning”, (“mathematical” or “math” or “math”), "journal", “proceedings”, "thesis", and “dissertation”. Primary studies that do not meet the inclusion criteria defined by the authors will be

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excluded from the meta-analysis study data at the screening stage. The aim is to avoid personal or selection bias in selecting studies identified by primary study searches (Khan, 2020).

Data analysis technique

The data analysis to be carried out was entirely completed with the help of the Comprehensive Meta-Analysis (CMA) Version 03 application. The steps in the data analysis to be carried out were calculating the effect size per study, bias test, heterogeneity test, overall effect test, and analysis of study characteristics, including educational level, sample size, and research demography. The effect size calculation is performed using Hedges' formula, which was selected because it provides a more accurate estimate of the effect size (Borenstein et al., 2009). The categorization of g values is classified into 5 categories (Juandi & Tamur, 2020): $\mathrm{ES} < 0.15$=neglected effect; 0.15≤ES<0.40=low effect; 0.40≤ES<0.75=moderate effect; 0.75≤ES<1.10=high effect; 1.10≤ES<1.45=very high effect; ES≥1.45=the effect is very good.

3. RESULTS AND DISCUSSION

In selecting the primary studies to be collected, the researcher follows the four steps in reporting meta-analysis, as outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) framework, which include identification, screening, eligibility, and inclusion. Through the results of the study selection, 46 primary studies were obtained related to the effect of implementing the Discovery Learning model on students' ability to understand mathematical concepts and 45 primary studies related to the impact of implementing the Discovery Learning model on students' mathematical reasoning abilities who had met the inclusion criteria set previously. Of the 46 and 45 primary studies, two studies produced two effect sizes. To obtain the final data, there are 48 primary studies related to conceptual understanding abilities and 47 primary studies related to reasoning abilities.

In the bias test, several studies cause bias, so it is necessary to exclude several studies. There are 7 primary studies related to the effect of the Discovery Learning model on students' ability to understand mathematical concepts, and 2 primary studies related to the impact of the Discovery Learning model on students' mathematical reasoning abilities, which need to be discarded in order to avoid publication bias. After removing the primary studies, the following results were obtained:

Table 2- Trim and fill test results after removing some primary studies.

Mathematical ability	Studies Trimmed	Hedge's g	Q-value
Concept Understanding Ability	0	0.84	83.66
Reasoning Ability	0	0.80	247.63

The effect of the discovery learning model on the overall understanding of mathematical concepts

The statistical meta-analysis model from the calculation results obtained in the form of a random effect model with a p-value (0.000) < α (0.05). The random effects model implies diversity in the results of various primary studies (Sari & Tanjung, 2022; Siegel et al., 2020). Furthermore, the results of other calculations will focus on the random effect model.

Table 3- Effect size ability to understand students' mathematical concepts based on the random effect model.

Number Studies	$\mathrm{p-value}$	$\mathrm{Z-value}$	Effect Size
41	0.000	13.771	0.845

Based on Table 3. The p-value is 0.000, which is smaller than α (0.05), indicating that implementing the discovery learning model affects the ability to understand students' mathematical concepts. These results also indicate that the discovery learning model provides a more effective influence than the comparison class, given the implementation of a model other than discovery learning. This finding also aligns with previous research, which states that the ability to understand concepts is influenced by the discovery learning model, with student responses when learning is very good (Caprio et al., 2019; Dazrullisa & Mahdi, 2020).

The effect of the calculation of 41 primary studies on the impact of the discovery learning model on students' ability to understand mathematical concepts is 0.845. The magnitude of this influence is interpreted as an effect size with a high effect category. These findings indicate that implementing the discovery learning model has a high influence on students' ability to understand mathematical concepts. This is supported by previous research, with an effect size value of 0.96; the application of the discovery learning model can improve students' understanding of mathematical concepts (Kufa & Susilowaty, 2022). Students' understanding of mathematical concepts increases due to the learning of the discovery learning model, where students are guided to find the mathematical concept itself.

Through the steps of discovery learning, students are expected to be able to process the mathematical information they are learning so that later they can make new conclusions about it (Ahmad et al., 2021). Students are allowed to discover the concepts they learn independently with various ideas or methods that they have, so that they can build and develop their understanding of the concepts they find. With this discovery process, the concepts he learns can be embedded in his memory for a longer time, or in other words, in long-term memory, which can later be recalled easily if he is faced with a problem that requires the concept (Agustina et al., 2019; Septiana et al., 2018). In this discovery learning step, students will more easily communicate the concepts they find and understand well (Ramadhani, 2017). Students will also find it easier to distinguish whether the concept is an example because it has gone through the process of collecting and processing information. Thus, the learning objectives of discovery learning are achieved by increasing the ability to understand students' mathematical concepts.

The influence of the discovery learning model on the ability to understand mathematical concepts in terms of study characteristics

Based on the results of the calculation of the heterogeneity of the overall effect size of the effect of the discovery learning model on students' ability to understand mathematical concepts, a statistical meta-analysis model was obtained in the form of a random effect model which showed that there were differences in the magnitude of the influence of each primary study analyzed. To find out this difference, a further review was carried out based on the characteristics of the study. This review was conducted to determine whether study characteristics such as educational level, sample size, and research demographics led to differences in research results from the analysed. The calculation results are presented in Table 4 below.

Table 4- Effect size on students' understanding of mathematical concepts from study characteristics.

Study Characteristics	Classification	Number Studies	Effect Size	Null Hypothesis Test		Heterogeneity		
				Z − value	p − value	Q-value	df (Q)	p − value
Educational Stage	Primary	1	0.600	2.303	0.021	7.731	2	0.021
	Junior High	11	0.904	8.209	0.000			
	Senior High	29	0.655	17.899	0.000			
Sample Size	< 30	17	0.850	11.562	0.000	0.149	1	0.699
	≥ 30	24	0.816	15.868	0.000			
Research Demographics	Sumatera	24	0.874	15.352	0.000	11.225	3	0.011
	Sulawesi	1	1.361	4.879	0.000			
	Jawa	12	0.662	9.096	0.000			
	Bali & Nusa Tenggara	4	1.008	7.371	0.000			

Through Table 4, it is obtained that the p-value of heterogeneity in educational level is 0.021 < α (0.05), which means that there is a difference in the effect of the implementation of the discovery learning model on the ability to understand students' mathematical concepts in terms of educational level. The greatest influence was at the junior high school education level, namely 0.904, with a high effect category. The high school education was followed by high school education, with an effect size of 0.655 in the medium effect category. Meanwhile, there is only one primary study. Therefore, the magnitude of the influence shown is not the cumulative result of several studies. This implies that the effect size of the primary education level cannot be compared with the effect size of the junior and senior high school education levels. Based on these results, it can be concluded that the application of the discovery learning model to understand students' mathematical concepts is more effectively used for students at the junior high school level of education. The explanation above is in line with several previous meta-analysis studies, Kufa & Susilowaty (2022) in their research obtained the result that at the junior high school education level the application of the discovery learning model had a greater effect than the high school education level, with an effect size of 1.08 in increasing mathematical ability student.

Understanding concepts at the junior high school education level is necessary and more effective because the concepts learned are still relatively simple, and the cognitive domains achieved are also not too high, so that all existing students can still follow them. In addition to this, based on Piaget's (1936) cognitive development, learning with the discovery learning model is also more effective for students at the secondary education level, namely at the formal operational stage. At this stage, students can solve problems and conclude systematically (Marinda, 2020). Students are also able to understand various opinions or views of other people (Ibda, 2015) so that it will be easy for them to participate in group discussions.

Educational level is a factor that causes differences in influence, but not in sample size. Based on the heterogeneity of the sample size, p-value 0.699 > α (0.05), which means that the implementation of the discovery learning model at a sample size of <30 or ≥30 has the same effect on students' ability to understand mathematical concepts. The research results obtained are in line with several previous meta-analysis studies, such as Anjarwati et al. (2022) in his research obtained the result that the application of the discovery learning model was not influenced by sample size on students' critical thinking abilities, both at sample sizes of 1-30 students and 31 students or more, both of which had an effect with a large effect category. Likewise, the research of Amelia et al. (2022) found that the sample size did not cause a difference in the implementation of the model on students' mathematical literacy abilities, both of which had a strong influence. Learning with the discovery learning model is knowing that it involves forming small groups it. The groups formed in discovery learning consist of 4 to 5 people

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(Cholid, 2021). Based on this, it is possible that there is no difference in effect on students who are in large and small class sizes.

Through Table 4, it is also obtained that the p-value of heterogeneity in research demographics is 0.011< (0.05), which means that there is a difference in the effect of the implementation of the discovery learning model on the ability to understand students' mathematical concepts in terms of research demographics. The biggest influence was on the demography of the Sulawesi research, which was 1.361, with a very high effect category. However, for the demographics of this Sulawesi study, there is only one primary study, so the magnitude of the influence shown is not the cumulative result of several studies. This implies that the demographic effect size of the Sulawesi study cannot be compared with the demographic effect sizes of other studies. Therefore, it cannot be said that the application of the discovery learning model to students' ability to understand mathematical concepts is more effective for students who are in Sulawesi.

The highest effect size was in the Bali and Nusa Tenggara research demographics, which was 1.008 in the high effect category. This was followed by the demography of the research on the island of Sumatra, with an effect size of 0.874 in the high effect category. Meanwhile, the Java Island research's demography has an effect size of 0.662 with a moderate effect category. Based on these results, it can be concluded that the application of the discovery learning model to understand students' mathematical concepts is more effectively used for students in the demographic research of the islands of Bali and Nusa Tenggara.

This result aligns with previous research that research on demography causes a significant difference in effect. Suparman et al. (2021b) explained that the demographic research on the islands of Bali and Nusa Tenggara has a higher influence than other islands, such as the islands of Kalimantan, Sumatra, Java, Sulawesi, and Maluku. Chin & Maat (2022) also explained that demography influences the anxiety of learning mathematics among students at the high school level, where learning anxiety also affects the ability to understand students' mathematical concepts (Awalia et al., 2021; Handayani, 2019). Thus, indirectly through these references, demography significantly influences the ability to understand students' mathematical concepts.

The effect of the discovery learning model on overall mathematical reasoning ability

The meta-analysis statistical model from the calculation results is obtained in the form of a random effect model, with a p-value (0.000) < α (0.05). The random effects model implies diversity in the results of various primary studies (Sari & Tanjung, 2022; Siegel et al., 2020). Furthermore, the results of other calculations will focus on the random effect model.

Table 5- Effect size of students' mathematical reasoning ability based on the random effect model.

Number Studies	$\mathrm{p-value}$	$\mathrm{Z-value}$	Effect Size
45	0.000	8.779	0.804

Based on Table 5, the p-value is 0.000, which is smaller than α (0.05). This can be interpreted as the implementation of the discovery learning model affecting students' mathematical reasoning abilities. These results also indicate that the implementation of the discovery learning model provides a more effective influence than the comparison class, given the implementation of a model other than discovery learning. This finding is also in line with previous research, which stated that there was an increase in students' mathematical reasoning abilities when the discovery learning model was carried out, where students were more actively involved and gave positive responses during learning (Septiani & Solehudin, 2019; Siregar et al., 2020).

The effect of the calculation of 45 primary studies of the effect of the discovery learning model on students' mathematical reasoning abilities is 0.804. The magnitude of this influence is interpreted as an effect size with a high effect category. These findings indicate that the discovery learning model highly influences students' mathematical reasoning abilities. With the discovery learning model, students are allowed to participate in thinking and reasoning to acquire their knowledge, not only by directly receiving the whole knowledge (Mahrifah & Samosir, 2019).

Through discovery learning steps, students are encouraged in learning actively and independently to reason and construct their mathematical knowledge (Mendrofa & Mendrofa, 2022). At the stage of identifying problems, it allows students to present these problems in writing or in the form of pictures, making it easier for them to carry out the next stage. Presenting mathematical statements orally, in writing, in pictures, and in diagrams indicates mathematical reasoning abilities. In addition, at this stage, students will also make conjectures or hypotheses on the problems that have been identified. This activity is also an indicator of mathematical reasoning ability (Ariati & Armiati, 2019). Data processing activities and mathematical proving processes will involve mathematical manipulation processes. This stage can develop students' mathematical reasoning abilities in doing mathematical manipulation. Furthermore, the conclusion drawing stage is very attached to mathematical reasoning ability because true reasoning ability is the ability to make a logical conclusion that can be proven true.

Based on the explanation above, discovery learning is hoped to run well so that students can be triggered to apply their reasoning abilities in carrying out the intended discovery process (Hadi, 2016; Khoir et al., 2018). This process is in line with research by Rosmini (2020) which applied the discovery learning model at several meetings, an increase in students' mathematical reasoning abilities was obtained where students were actively able to express conjectures in the question-and-answer activity carried out by the teacher and were able to conclude what had just been learned. Thus, it can be concluded that carrying out discovery learning activities will be able to improve students' mathematical reasoning abilities.

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The influence of the discovery learning model on mathematical reasoning ability viewed from study characteristics

Based on the results of the calculation of the heterogeneity of the overall effect size of the effect of the discovery learning model on students' mathematical reasoning abilities, a statistical meta-analysis model was obtained in the form of a random effect model which showed that there were differences in the magnitude of the influence of each primary study analyzed. To examine this difference, a further review was carried out based on the characteristics of the study. This review determined whether study characteristics such as educational level, sample size, and research demographics led to differences in research results from the analysis. The calculation results are presented in Table 6 below.

Table 6- Effect size of students' mathematical reasoning ability given study characteristics.

Study Characteristics	Classification	Number Studies	Effect Size	Null Hypothesis Test		Heterogeneity		
				$\mathrm{Z-value}$	$\mathrm{p-value}$	Q-value	df(Q)	P-value
Educational Stage	Primary	3	0.920	5.431	0.000	0.942	2	0.624
	Junior High	34	0.752	17.008	0.000			
	Senior High	8	0.779	8.897	0.000			
Sample Size	< 30	6	1.016	8.181	0.000	4.470	1	0.034
	≥ 30	39	0.740	18.290	0.000			
Research Demographics	Sumatera	18	0.675	10.862	0.000	3.526	2	0.172
	Sulawesi	2	0.802	3.725	0.000			
	Jawa	25	0.824	16.390	0.000			

Table 6 shows that the p-value for heterogeneity in educational level is 0.624 < α (0.05), which means that the discovery learning model at the primary school, junior high school, and senior high school educational levels has the same effect on students' mathematical reasoning abilities. This result is in line with several previous meta-analysis studies, Rohmatulloh et al. (2022) in his research obtained results that at the junior and senior high school education levels both had an equally suitable influence in improving students' mathematical reasoning abilities through the application of the Problem Based Learning (PBL) model with a similarly strong effect. Likewise, with the research of Suparman et al. (2021a) in research, it obtained the result that there was no difference in impact on educational level, both for elementary, junior high, high school, and college students.

Based on the findings, which identified no difference in effect on educational level, it can be interpreted that the level of topic, material, and difficulty of math assignments had been prepared as well as possible and adjusted to the stage of cognitive development of students following the intended educational level. Reasoning at the elementary education level is in the form of transitivity or relationships between classes, where students can combine relationships logically to understand a certain conclusion (Marinda, 2020). In contrast to reasoning at the secondary education level, their reasoning is marked by the presence of the ability to think and compile more abstract ideas, where they are already able to formulate hypotheses or estimates of the possible answers to these problems to reach an expected conclusion (Mutammam & Budiarto, 2013).

Unlike the level of education, the sample size causes differences in the effect of the discovery learning model on students' mathematical reasoning abilities. The greatest impact was on a sample size of less than 30, namely 1.016, with a high effect category. Meanwhile, if the sample size is more than or equal to 30, it will give an effect size of 0.740 in the medium effect category. Based on these results, it can be concluded that applying the discovery learning model to students' mathematical reasoning abilities is more effective when used in classes with fewer than 30 students.

Some education experts state that classroom learning activities at the primary and secondary school levels would be ideal if the number of students consists of 24 people or the teacher-student ratio is 1:24 (Mukhtar & Iskandar, 2012; Mulyono, 2012). With fewer students, students will concentrate more on the lessons they receive (Usman, 2017). This is because the learning activities with relatively fewer students will feel more comfortable and calmer. In addition to influencing the learning atmosphere in the classroom, the size of the class can also affect their self-confidence (Ali, 2014; Bakar et al., 2016). The smaller number of students will also affect the accuracy of the teacher in evaluating each student (Ramana, 2011; Wright et al., 2019).

Table 6 also shows that the p-value of research demographic heterogeneity is 0.172 < α (0.05). This means that the discovery learning model for demographic research on the islands of Sumatra, Sulawesi, and Java has the same effect on students' mathematical reasoning abilities. The results obtained are in line with the research of Suparman et al. (2021a) from an analysis of 18 primary studies. it was found that there was no difference in influence on the research demography between Bali and Nusa Tenggara, Java, Sumatra, Sulawesi, and Maluku. The four classifications of the research demographics are in the high effect category. The research results by Ruswandi (2022) also suggest that demographics are far away, even if the distance between students and schools does not necessarily affect their learning outcomes. This did not immediately dampen their enthusiasm for learning. If students are serious about learning well, no matter what the circumstances, they will also get good results. Therefore, student motivation in learning greatly influences their learning outcomes (Sumartiningsih and Sari, 2019).

4. CONCLUSION

Based on the results of the research and discussion described previously, through 41 primary studies which were further analyzed, it was found that the implementation of the discovery learning model affected the ability to understand mathematical concepts as a whole. Educational level and research demographics lead to differences in influence, where junior high school and research demographics on the islands of Bali and Nusa Tenggara provide a more effective influence. However, the sample size did not cause any difference in the effect of the discovery learning model on students' ability to understand mathematical concepts. Furthermore, through 45 primary studies were further analyzed, it was found that the implementation of the discovery learning model affected overall mathematical reasoning abilities. The sample size causes a difference in effect, where classes with fewer than 30 students have a more effective impact. However, educational level and research demographics did not cause any differences in the impact of the discovery learning model on students' mathematical reasoning abilities.

6. REFERENCES

Agustina, M., Gunowibowo, P., & Wijaya, A. P. (2019). Pengaruh model penemuan terbimbing terhadap pemahaman konsep matematis. Jurnal Pendidikan Matematika Unila, 7(2), 194–208. http://repository.lppm.unila.ac.id/15379/

Ahmad, F. S., Minggi, I., & Bahar, E. E. (2021). Pengaruh penerapan model discovery learning berbasis kontekstual terhadap kemampuan pemahaman konsep matematika siswa kelas vii SMP Negeri 2 Barombong. Jurnal Riset Dan Inovasi Pembelajaran, 1(1), 53–63. https://doi.org/10.51574/jrip.v1i1.17

Ahmad, H. (2015). Peningkatan kemampuan penalaran matematika materi trigonometri melalui penerapan model pembelajaran discovery learning dengan pendekatan saintifik pada kelas x SMA Negeri 11 Makassar. Jurnal Daya Matematis, 3(3), 299–307. https://doi.org/10.26858/jds.v3i3.1697

Ali, M. (2014). Guru dalam Proses Belajar Mengajar. Sinar Baru Algensindo.

Amelia, I., Syamsuri, Santosa, C. A. H. F., & Fatah, A. (2022). Meta analisis : pengaruh model pembelajaran terhadap kemampuan literasi matematis siswa. Jurnal Cendekia: Jurnal Pendidikan Matematika, 6(2), 1720–1730.

Anjarwati, D., Juandi, D., Nurlaelah, E., & Hasanah, A. (2022). Studi meta-analisis: pengaruh model discovery learning berbantuan geogebra terhadap kemampuan berpikir kritis matematis siswa. Jurnal Cendekia : Jurnal Pendidikan Matematika, 6(3), 2417–2427. https://doi.org/10.31004/cendekia.v6i3.1506

Ariati, C., & Armiati. (2019). Pengaruh model discovery learning terhadap kemampuan penalaran matematis peserta didik kelas vii SMPN 2 2x11 Kayu Tanam tahun pelajaran 2018/2019. Jurnal Edukasi Dan Penelitian Matematika, 8(1), 19–26. https://doi.org/10.36709/jppm.v6i1.7406

Asmianti, P. I. A., & Agustyarini, Y. (2021). Efektivitas metode penemuan terbimbing (guided discovery) terhadap kemampuan penalaran matematis siswa kelas v materi pecahan. Journal of Mathematics Education and Learning, 1(3), 287–298. https://doi.org/10.19184/jomeal.v1i3.27654

Awalia, A., Lambertus, & Anggo, M. (2021). Pengaruh kecemasan matematika terhadap pemahaman konsep matematis siswa kelas vii SMP Negeri 2 Raha. Jurnal Penelitian Pendidikan Matematika, 9(2), 197–210.

Bakar, A. A., Nursalam, & Mardhiah. (2016). Pengaruh model pembelajaran aptitude treatment interaction (ati) terhadap hasil belajar matematika siswa ditinjau dari ukuran kelas ix Sekolah Menengah Pertama (SMP) Negeri di Kecamatan Pattallassang Kab. Gowa. Jurnal Matematika Dan Pembelajaran (MAPAN), 4(1), 46–69.

Bloom, J. De, Kompier, M., Geurts, S., Weerth, C. De, Taris, T., & Sonnentag, S. (2009). Do we recover from vacation? meta-analysis of vacation effects on health and well-being. Journal of Occipational Health, 51(1), 13–25.

Borenstein, M., Hedges, L. V, Higgins, J. P. T., & Rothstein, H. R. (2009). Introduction to meta-analysis. In Wiley. Wiley. https://doi.org/10.1007/978-3-319-14908-0_2

Caprio, R. R., Noer, S. H., & Wijaya, A. P. (2019). Pengaruh model pembelajaran discovery learning terhadap pemahaman konsep matematis siswa. Jurnal Pendidikan Matematika, 7(5), 630–644.

Chin, S. H., & Maat, S. M. (2022). Sorotan Literatur Bersistematik: faktor yang mempengaruhi kebimbangan matematik dalam kalangan pelajar sekolah menengah. Malaysian Journal of Social Sciences and Humanities (MJSSH), 7(9), 1–20. https://doi.org/10.47405/mjssh.v7i9.1790

Cholid, N. (2021). Menjadi Guru Profesional. Presisi Cipta Media.

Dazrullisa, & Mahdi, T. C. (2020). Pengaruh penggunaan model pembelajaran discovery learning terhadap pemahaman konsep matematis siswa dengan menggunakan geometric sketcpad. Jurnal Numeracy, 7(1), 1–19. https://doi.org/10.46244/numeracy.v7i1.995

Eskris, Y. (2021). Meta analisis pengaruh model discovery learning dan problem based learning terhadap kemampuan berfikir kritis peserta didik kelas v sd. Jurnal Pendidikan Guru Sekolah Dasar, 2(1), 43–52.

Fuadi, R., Johar, R., & Munzir, S. (2016). Peningkatkan kemampuan pemahaman dan penalaran matematis melalui pendekatan kontekstual. Jurnal Didaktika Matematika, 3(1), 47–54.

Glass, G. V. (1976). Primary, Secondary, and Meta-Analysis of Research. American Educational Research Association, 5(10), 3–8.

Hadi, W. (2016). Meningkatkan kemampuan penalaran siswa smp melalui pembelajaran discovery dengan pendekatan saintifik (studi kuasi eksperimen di salah satu smp jakarta barat). Jurnal Pendidikan Matematika, 1(1), 93–108.

Handayani, S. D. (2019). Pengaruh kecemasan matematika terhadap pemahaman konsep matematika. SAP (Susunan Artikel Pendidikan), 4(1), 59–65. https://doi.org/10.30998/sap.v4i1.3708
Harisuddin, M. I. (2020). Penerapan discovery learning untuk meningkatkan kemampuan pemahaman konsep matematis siswa SMPN 1 Pagaden. Jurnal Mitra Pendidikan (JMP Online), 4(2), 52–61.
Hermawan, A. S., & Hidayat, W. (2018). Meningkatkan kemampuan penalaran matematik siswa smp melalui pendekatan penemuan terbimbing. JPMI (Jurnal Pembelajaran Matematika Inovatif), 1(3), 7–12. https://doi.org/10.22460/jpmi.v1i1.p7-12
Hunter, J. E., & Schmidt, F. L. (2004). Methods of Meta-Analysis: Correcting Error and Bias in Research Findings. SAGE Publications.
Ibda, F. (2015). Perkembangan kognitif: teori jean piaget. Jurnal Intelektualita, 3(1), 27–38.
Ibrahim, & Suparni. (2012). Pembelajaran Matematika: Teori dan Aplikasinya. SUKA-Press UIN Sunan Kalijaga.
JDIH. (2022). Standar Isi Pada Pendidikan Anak Usia Dini, Jenjang Pendidikan Dasar, dan Jenjang Pendidikan Menengah. JDIH Kemenristekdikbud.
Juandi, D., & Tamur, M. (2020). Pengantar Analisis Meta. UPI Press.
Juandi, D., & Tamur, M. (2021). The impact of problem-based learning toward enhancing mathematical thinking : a meta-analysis study. Journal of Engineering Science and Technology, 16(4), 3548–3561.
Karlina, L., & Anugraheni, I. (2021). Meta analisis model discovery learning untuk meningkatkan hasil belajar matematika siswa sd. Jurnal Pendidikan Matematika Indonesia, 6(1), 35–43.
Khairunnisa, & Amry, Z. (2021). The influence of study habits and self-concept on students' mathematical reasoning ability. Desimal: Jurnal Matematika, 4(3), 315–324. https://doi.org/10.24042/djm.v4i3.10154
Khan, S. (2020). Meta-Analysis: Methods for Health and Experimental Studies. Springer.
Khofifah, L., Supriadi, N., & Syazali, M. (2021). Model flipped classroom dan discovery learning terhadap kemampuan pemahaman konsep dan pemecahan masalah matematis. Prisma, 10(1), 17–29. https://doi.org/10.35194/jp.v10i1.1098
Khoir, N. L., Winarti, E. R., & Agoestanto, A. (2018). Spesifikasi literasi siswa berdasarkan kemampuan penalaran adaptif pada discovery learning berpendekatan saintifik berbantuan media. PRISMA, Prosiding Seminar Nasional Matematika, 1, 371–380.
Kholili, A., Shoffa, S., & Soemantri, S. (2021). Pembelajaran matematika model discovery learning terhadap kemampuan berpikir kreatif siswa : kajian meta analisis. JPMI (Jurnal Pembelajaran Matematika Inovatif), 4(6), 1441–1452. https://doi.org/10.22460/jpmi.v4i6.1441-1452
Kufa, W. E., & Susilowaty, N. (2022). Meta analisis pengaruh model pembelajaran discovery learning terhadap kemampuan matematis siswa. Jurnal Padegogik, 5(2), 32–42. https://jurnal.unai.edu/index.php/jpd/article/view/2894
Laili, N., Purwanto, S. E., & Alyani, F. (2019). Pengaruh model penemuan terbimbing berbantu lkpd terhadap kemampuan pemahaman konsep matematis siswa SMPN 6 Depok. International Journal of Humanities, Management and Social Science, 2(1), 14–37. https://doi.org/0.36079/lamintang.ij-humass-0201.20
Lestari, F. P., & Ristontowi. (2021). Kemampuan pemahaman konsep matematika siswa sma pada model discovery learning dan model auditory intellectually repetition. Indiktika: Jurnal Inovasi Pendidikan Matematika, 4(1), 46–54.
Lipsey, M. W., & Wilson, D. B. (2001). Practical meta ¬ analysis: applied social research methods series (Vol. 49). SAGE Publications.
Mahmudah, U. (2021). Meta analisis pengaruh model discovery learning dan problem based learning terhadap kemampuan berfikir kritis peserta didik kelas v sd. Jurnal Pendidikan Guru Sekolah Dasar, 2(1), 43–52.
Mahrifah, & Samosir, K. (2019). Perbedaan kemampuan penalaran matematis siswa menggunakan model pembelajaran discovery learning dengan model pembelajaran problem-based learning siswa kelas viii MTS Negeri Siabu. Jurnal Inspiratif, 5(2), 12–23.
Marinda, L. (2020). Teori perkembangan kognitif jean piaget dan problematikanya pada anak usia sekolah dasar. An-Nisa': Jurnal Kajian Perempuan & Keislaman, 13(1), 116–152.
Mendrofa, N. K., & Mendrofa, R. N. (2022). Pengaruh model pembelajaran discovery learning dengan pendekatan saintifik terhadap kemampuan penalaran matematis siswa SMP. Jurnal Education and Development, 10(2), 535–537. http://repo.iain-tulungagung.ac.id/id/eprint/9530
Mercy, T., Frederick-Jonah, & Akinsola, M. K. (2015). Enhancing pupils' knowledge of mathematical concepts through game and poem. IOSR Journal of Research & Method in Education, 5(2), 60–66. https://doi.org/10.9790/7388-05216066
Mukhtar, & Iskandar. (2012). Desain Pembelajaran Berbasis Teknologi Informasi dan Komunikasi (Sebuah Orientasi Baru). Gaung Persada Press.
Mulyono. (2012). Strategi Pembelajaran Menuju Efektivitas Pembelajaran di Abad Global. UIN Maliki Pers.
Munasiah, M., Solihah, A., & Heriyati, H. (2020). Pemahaman konsep dan penalaran matematika siswa dalam pembelajaran matriks. SAP (Susunan Artikel Pendidikan), 5(1), 73–78. https://doi.org/10.30998/sap.v5i1.6231
Mutammam, M. B., & Budiarto, M. T. (2013). Pemetaan perkembangan kognitif piaget siswa SMA menggunakan tes operasi logis (tol) piaget ditinjau dari perbedaan jenis kelamin. MATHEdunesa, 2(2), 1–6. https://jurnalmahasiswa.unesa.ac.id/index.php/mathedunesa/article/view/2701/5684
NCTM. (2000). Principles and Standards for School Mathematics. nctm.org.
Nindrea, R. D. (2016). Pengantar Langkah-Langkag Praktis: Studi Meta Analisis. Gosyen Publishing.
Novitasari, L., & Leonard. (2017). Pengaruh kemampuan pemahaman konsep matematika terhadap hasil belajar matematika. Prosiding Diskusi Panel Nasional Pendidikan Matematika, 758–766.

DOI: https://doi.org/10.17509/ije.v18i1.54959
p- ISSN 1978-1342 e- ISSN 2442-4730

Nugroho, A. A., Dwijayanti, I., & Atmoko, P. Y. (2020). Pengaruh model pembelajaran berbasis penemuan dan matematika melalui meta analisis. AKSIOMA: Jurnal Program Studi Pendidikan Matematika, 9(1), 147–157.
Pahmi, S. (2020). Meningkatkan kemampuan mathematical reasoning dalam pembelajaran matematika siswa sekolah menengah menggunakan discovery learning. Jurnal BELAINDIKA (Pembelajaran Dan Inovasi Pendidikan), 2(1), 32–40. https://doi.org/10.52005/belaindika.v2i1.28
Putro, S. S. N., Soenarto, M., & Faradillah, A. (2019). Pengaruh model discovery learning berbantu software wingeom terhadap kemampuan pemahaman konsep matematis peserta didik. Majamath, 2(1), 72–79.
Rahman, T., & Maya, N. (2017). Pengaruh pembelajaran berbasis penemuan terbimbing terhadap peningkatan kemampuan penalaran matematis. PYTHAGORAS: Jurnal Program Studi Pendidikan Matematika, 6(2), 167–174. https://doi.org/10.33373/pythagoras.v6i2.899
Ramadhani, R. (2017). Peningkatan kemampuan pemahaman konsep dan kemampuan pemecahan masalah matematika siswa sma melalui guided discovery learning berbantuan autograph. Jurnal Penelitian Dan Pembelajaran Matematika, 10(2), 72–81. https://doi.org/10.30870/jppm.v10i2.2032
Ramana, L. (2011). Teaching Large Classes: Problem & Prospects. Educreation Publishing.
Rohmatulloh, Syamsuri, Nindiasari, H., & Fatah, A. (2022). Analisis meta: pengaruh model pembelajaran problem based learning (pbl) terhadap kemampuan penalaran matematis siswa. Jurnal Cendekia: Jurnal Pendidikan Matematika, 6(2), 1558–1567.
Rolina, R., Aryani, S., & Taufiqurrohman, E. (2018). Comparison of the ability of mathematical reasoning of smk students using a metacognitive skill approach through advance organizer learning models with a saintific approach through discovery learning. Journal of Innovative Mathematics Learning, 1(3), 233–238.
Rosmini, N. (2020). Pengaruh model pembelajaran penemuan terbimbing dalam meningkatkan kemampuan penalaran dan sikap matematis siswa. Jurnal Pedagogik Pendidikan Dasar, 7(1), 35–48.
Ruswandi. (2022). Pengaruh kondisi geografis terhadap hasil belajar siswa di SDN 01 Simego. ELEMENTARY: Jurnal Inovasi Pendidikan Dasar, 2(1), 56–65.
Saputra, S., Fatimah, S., & Priatna, B. A. (2016). Increasing junior high school students' mathematical reasoning ability by using guided discovery learning. International Conference on Mathematics, Science, and Education, 70–73.
Sari, Y. K., & Tanjung, S. (2022). Meta analisis terhadap pengaruh pembelajaran inkuiri: dalam pemecahan masalah matematis siswa SLTP. Edu Publisher.
Septia, A., Caswita, & Gunowibowo, P. (2018). Efektivitas model discovery learning ditinjau dari pemahaman konsep matematis peserta didik. Jurnal Pendidikan Matematika Unila, 6(7), 729–740.
Septiana, K. R. A., Parwati, N. N., & Hartawan, I. G. N. Y. (2018). Efektivitas model pembelajaran penemuan terbimbing berbantuan geogebra terhadap pemahaman konsep matematika siswa smp. Jurnal Pendidikan Matematika Undiksha, 9(1), 22–33. https://doi.org/10.23887/jjpm.v9i1.19878
Septiani, N. I., & Solehudin, S. (2019). Pembelajaran matematika dengan menggunakan metode penemuan terbimbing untuk meningkatkan kemampuan penalaran induktif siswa smp. Pasundan Journal of Mathematics Education : Jurnal Pendidikan Matematika, 9(2), 120–135. https://doi.org/10.23969/pjme.v9i2.4123
Siegel, L., Murad, M. H., & Chu, H. (2020). Estimating the reference range from a meta-analysis. Research Synthesis Methods, 12(2), 1–13. https://doi.org/10.1002/jrsm.1442
Silviana, D., & Novitasari, D. (2018). Pengaruh model pembelajaran discovery learning berbantuan lks terhadap pemahaman konsep matematika siswa pada materi teorema pythagoras. Jurnal Evolusi MIPA, 2(1), 105–113.
Simanjuntak, E. (2017). Perbandingan kemampuan penalaran siswa menggunakan model pembelajaran discovery learning dengan model pembelajaran problem based learning berbantuan wingeom. Generasi Kampus, 10(1), 39–50.
Siregar, N. C., Rosli, R., & Maat, S. M. (2020). The effects of a discovery learning module on geometry for improving students' mathematical reasoning skills, communication and self-confidence. International Journal of Learning, Teaching and Educational Research, 19(3), 214–228. https://doi.org/10.26803/ijlter.19.3.12
Sugianto, Armanto, D., & Harahap, M. B. (2014). Perbedaan penerapan model pembelajaran kooperatif tipe jigsaw dan komunikasi matematis siswa sma. Jurnal Didaktik Matematika, 1(1), 96–128.
Sumartiningsih, D., & Sari, L. D. K. (2019). Pengaruh gaya dan motivasi belajar terhadap kemampuan penalaran matematis. EDUSAINTEK: Jurnal Pendidikan Sains Dan Teknologi, 6(1), 107–114.
Suparman, Juandi, D., & Tamur, M. (2021a). Problem-based learning for mathematical critical thinking skills : a meta-analysis. Journal of Hunan University (Natural Sciences), 48(2), 133–144.
Suparman, Juandi, D., & Tamur, M. (2021b). Review of problem-based learning trends in 2010-2020: a meta-analysis study of the effect of problem-based learning in enhancing mathematical problem-solving skills of indonesian students. Journal of Physics: Conference Series, 1722, 1–9. https://doi.org/10.1088/1742-6596/1722/1/012103
Usman, M. U. (2017). Menjadi Guru Profesional. Remaja Rosa Karya.
Wright, M. C., Bergom, I., & Bartholomew, T. (2019). Decreased class size, increased active learning? intended and enacted teaching strategies in smaller classes. Active Learning in Higher Education, 20(1), 51–62. https://doi.org/10.1177/1469787417735607

DOI: https://doi.org/10.17509/ije.v18i1.54959
p- ISSN 1978-1342 e- ISSN 2442-4730