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THE EFFECT OF DISCOVERY LEARNING MODEL ON STUDENTS' MATHEMATICAL COMMUNICATION SKILLS: META ANALYSIS

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ABSTRACT

One important aspect in improving students' mathematical communication ability is the use of the right learning model, one of which is through the Discovery Learning (DL) model. The purpose of writing this article is to find out how much influence the DL model has on student performance. This study is important because it provides a thorough review of the effectiveness of the DL model based on findings from various previous studies. The method used is SLR with meta-analysis guidelines for ten articles, using Cohen's formula to calculate the effect size value. The results showed one article in the medium category (0.47) and nine others in the very large category (1.046-7.27). This finding shows that Discovery Learning is effective in improving mathematical communication skills. This article contributes to strengthening the empirical foundation and provides recommendations for the application of this model in mathematics learning practices.

Keywords*: Meta Analysis, Learning Model, Discovery Learning, Mathematical Communication, Mathematics.*

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INTRODUCTION

In learning mathematics, every student must have the ability to think mathematically which is called mathematical ability. Among the many mathematical abilities, mathematical communication ability (MCI) plays an important role in the delivery of mathematics material. This ability includes students' skills in representing problems or ideas in mathematics using real objects, images, or tables, and can use mathematical symbols (Wildaniati, at. al., 2021). This ability is needed to help students in problem solving.

Therefore, the role of the teacher is very important in guiding and creating a learning environment that allows students to express their mathematical ideas. However, the reality in the field shows that in learning mathematics is still dominated by the use of the lecture method so that students only act as listeners. The lack of careful selection of learning models by teachers is one aspect that affects the low KKM of students (Pratiwi, at. al., 2024).

Discovery Learning (DL) is one of the learning models that can be used to overcome this problem. This model places students as the centre of learning activities, thus encouraging them to be more active in exploring their own knowledge. Through direct involvement in the process, students get wider opportunities to develop their mathematical communication skills. (Habibi, at. al., 2019). Therefore, this model is believed to be able to improve mathematical communication skills more optimally.

Some studies show that the use of the DL model has a positive impact on students' KKM. For example, research by Fazriansyah shows that the DL model is effective in improving the KKM of class X students of SMA Negeri 3 Tasikmalaya (Fazriansyah, 2023). Research conducted by Rachma and Winanto found an increase in the average KKM evaluation results of students in class V-A SD Negeri Sidorejo Lor 03 Salatiga in two cycles. This study showed an increase in student KKM in the second cycle. The average score, which was initially 73.5 in the first cycle, increased to 83.5 in the second cycle (Rachma & Winanto, 2024). In addition, research conducted by Giawa, et al. found an *Effect Size* (ES) value of 0.81 which means that the effectiveness of the DL model in improving the KKM of class X students at SMK Negeri 1 Lumut (Giawa, at. al.,. 2021).

Several meta-analysis studies on the effect of the DL model have been conducted by previous researchers with a focus on different mathematical abilities. For example, research by Kufa and Susilowaty which focused on students' mathematical ability, found a large effect with a value of 1.05 on its ES (Kufa & Susilowaty, 2022). Furthermore, research with a focus on students' creative thinking skills conducted by Kholili, at. al. (2021) also produced a large ES category on the material of building space with a value of 2.84. In addition, research by (Suwarno, at. al., 2022) also contributed a very large ES value to the effect of the DL model on critical thinking skills. An ES value of 1.9 was obtained on flat building material at the elementary level. 2.1 on social arithmetic material at the junior high school level and 1.18 on statistics material at the high school level.

In contrast to these studies, this study specifically examines the effect of DL models on student performance, an aspect that is very important in mathematics learning but has not been studied in a focused manner in the form of a meta-analysis. Although a number of studies have shown positive results on this aspect, there is no comprehensive mapping that illustrates the magnitude and consistency of the effect. Therefore, this article is organised in the form of a meta-analysis to summarise and conclude previous findings related to the effect of DL models on student achievement.

RESEARCH METHOD

This study uses the Systematic Literature Review (SLR) method combined with quantitative meta-analysis techniques, and refers to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The approach used is descriptive quantitative, because the main focus of this study is to calculate the magnitude of the influence of the Discovery Learning model on students' mathematical communication skills based on numerical data from various previous experimental studies.

This research is a library research based on meta-analysis, with a quantitative approach. The aim is to combine the results of previous relevant experimental studies to obtain stronger statistical conclusions and broader generalisations regarding the influence of the Discovery Learning model on mathematical communication skills.

Data in this study were collected through a systematic search of relevant journal articles using the Google Scholar search engine with the keywords ‘Discovery Learning’

and 'Mathematical Communication' between 2015 and 2025. The article selection process used the PRISMA flow, which includes the stages of identification, screening, eligibility assessment, and final inclusion. Only articles that met the inclusion criteria, such as being experiment-based and having complete data (mean and standard deviation for the experimental and control classes), were analysed further.

All ES calculation results from the selected articles are presented in a table and analysed to draw general conclusions about the effectiveness of the learning model.

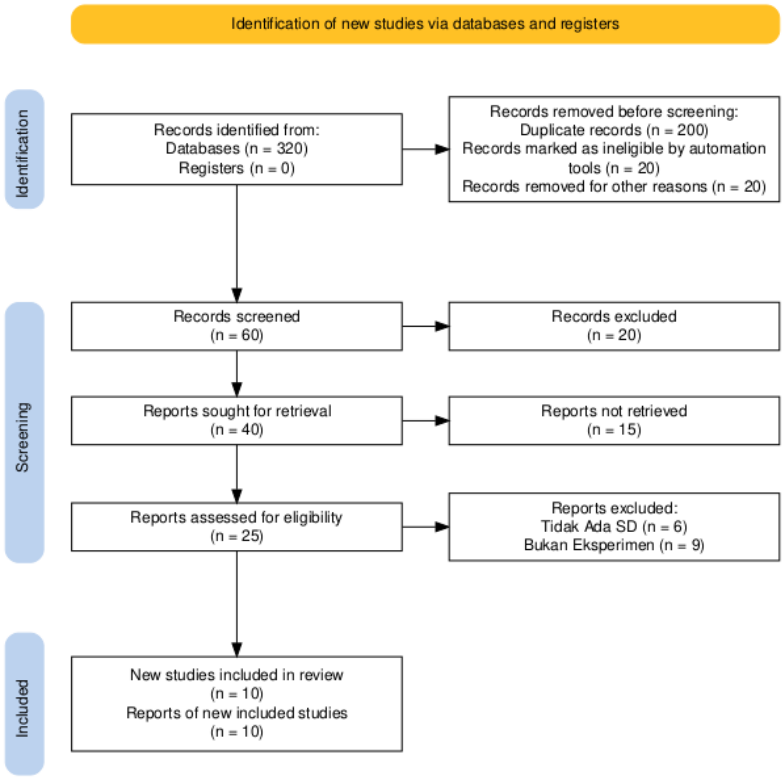

Figure 1 Article selection process based on PRISMA

Searching for relevant articles on Google Schoolar using the PRISMA method resulted in 320 articles with the keywords "*Discovery Learning*" and "Mathematical Communication". Then exclusion was carried out resulting in 10 articles that will be reviewed by meta-analysis. Meta analysis is a systematically conducted study that combines the results of several relevant studies using statistical techniques to obtain stronger conclusions (Parwata, 2021). The exclusion and inclusion criteria used to obtain the articles to be analysed can be seen in table 1.

Table 1I
Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
National or international scientific articles related to DL and student KKMs	Compilation of scientific articles that cannot be accessed in full

Scientific article using experimental research complete with mean scores, and standard deviation of control and experimental classes	Scientific articles that do not use experimental methods

Inclusion criteria are criteria used to select members of the population who fulfil theoretical requirements and are relevant to the research topic. In contrast, exclusion criteria refer to the criteria used to exclude members from the sample who do not meet the inclusion criteria (Kholili, at. al., 2021). Based on the selection process, the researcher obtained 10 articles that were suitable for further analysis. The articles are presented in Table II, which contains some important information.

Table 2 List of articles used

Article Code	Researcher	Year	Journal
A1	Imas Kanah and Dian Mardiani	2022	Plusminus: Journal of Mathematics Education
A2	Riska Asmara and Ekasatya Aldila Afriansyah	2018	Suska Journal of Mathematics Education
A3	Ranti Santika Dewi, Rostina Sundayana, and Reni Nuraeni	2020	Mosharafa: Journal of Mathematics Education
A4	Asep Habibi, Nita Delima, Yanry Budianingsih	2019	BIORMATIKA Scientific Journal of FKIP Universitas Subang
A5	Jarwan	2018	PROXIMAL Journal of Research in Mathematics and Mathematics Education
A6	Endi Zunaedy Pasaribu	2017	MAJU: Scientific Journal of Mathematics Education
A7	Zinatun Hayati Dina, M. Ikhsan, Hajidin	2019	Journal of Research and Advances in Mathematics Education
A8	Raju Parlindungan, Rini Asnawati, Agung Putra Wijaya	2019	Journal of Mathematics Education
A9	Puspita Nur Ariesta, Subhan Ajiz Awallusin	2021	Journal of Authentic Research on Mathematics Education (JARME)
A10	Merisa Yayu Mutiara Ibay Yani, Heris Hendriana, Siti Chotimah	2024	Journal of Innovative Mathematics Learning

In order to determine the extent of the effect of the DL model on KKM based on the article above, the *Effect Size* (ES) calculation was carried out using the cohen's formula as follows (Marlina et al., 2021):

ES formula for one sample group: $ES = \frac{\bar{X}_{post} - \bar{X}_{pre}}{SD_{pre}}$

ES formula for two sample groups: $ES = \frac{\bar{X}_E - \bar{X}_C}{SD_C}$

Description:

ES : *Effect Size*
$\bar{X}_{pre}$: Mean Pretest
$\bar{X}_{post}$: Mean Posttest
$\bar{X}_E$: Mean Experiment
$\bar{X}_C$: Mean Control
SD_{Pre} : Standard Deviation Pretest
SD_C : Standard Deviation Control

The ES value obtained is then interpreted based on the following criteria (Yustinaningrum, 2021) :

Table 3 ES Interpretation

ES	Interpretation
0 < d < 0,2	Small
0,21 < d ≤ 0,50	Medium
0,51 < d ≤ 1,00	Great
d > 1,00	Very Large

RESULTS AND DISCUSSION

The ten selected articles were analysed using Cohen's formula. This analysis was conducted to determine the extent to which the *DL* model contributed to the improvement of students' KKM. A summary of the data from the ten articles is presented in the following table:

Table 4 ES Article

Article Code	Value		*Effect Size*	Category
A1	One Sample Group		$\frac{12{,}25 - 2{,}75}{1{,}68} = 5{,}65$	Very Large
	Pretest Mean = 2.75 SD = 1.68	*Posttest* Mean = 12.25 SD = 2.65		
A2	One Sample Group		$\frac{7{,}3 - 4}{2{,}17}$	Very Large
	Pretest Mean = 4	*Posttest* Mean = 7.3		

	SD = 2.17	SD = 3.22	$= 2{,}75$	
A3	One Sample Group		$\frac{8{,}97 - 0{,}97}{1{,}10}$ $= 7{,}27$	Very Large
	Pretest Mean = 0.97 SD = 1.10	*Posttest* Mean = 8.97 SD = 2.15		
A4	Two Sample Groups		$\frac{12{,}10 - 9{,}90}{1{,}69}$ $= 1{,}3$	Very Large
	Experiment Mean = 12.10 SD = 1.92	*Control* Mean = 9.90 SD = 1.69		
A5	One Sample Group		$\frac{80{,}47 - 55{,}99}{9{,}04}$ $= 2{,}71$	Very Large
	Pretest Mean = 55.99 SD = 9.04	*Posttest* Mean = 80.47 SD = 8.07		
A6	One Sample Group		$\frac{85{,}72 - 47{,}92}{23{,}55}$ $= 1{,}6$	Very Large
	Pretest Mean = 47.92 SD = 23.55	*Posttest* Mean = 85.72 SD = 17.91		
A7	Two Sample Groups		$\frac{84{,}3 - 80{,}6}{7{,}9}$ $= 0{,}47$	Medium
	Experiment Mean = 84.3 SD = 8.15	*Control* Mean = 80.6 SD = 7.9		
A8	One Sample Group		$\frac{7{,}8 - 2{,}57}{1{,}61}$ $= 3{,}25$	Very Large
	Pretest Mean = 2.57 SD = 1.61	*Posttest* Mean = 7.8 SD = 5.8		
A9	Two Sample Groups		$\frac{62{,}366 - 54{,}913}{7{,}125}$ $= 1{,}046$	Very Large
	Experiment Mean = 62.366 SD = 5.061	*Control* Mean = 54.913 SD = 7.125		
A10	Two Sample Groups		$\frac{10{,}10 - 7{,}58}{1{,}89}$ $= 1{,}33$	Very Large
	Experiment Mean = 10.10 SD = 3.94	*Control* Mean = 7.58 SD = 1.89		

The first article Kanah & Mardiani (2022) shows the positive effect of the DL model on the KKM of students in class X MIPA 7 at SMA 6 Garut. This is evidenced by the students' KKM which increased after the use of the DL model in learning. The ES value of 5.65 also shows that the effect is included in the very high category.

The second article Asmara & Afriansyah (2018) shows that, on the material of relations and functions, the DL model can increase the KKM of students in class X MIPA 7 at SMA Negeri 15 Garut. ES in the second article is worth 2.75, which means that this model has a very big influence on student KKM.

The third article Dewi, at. al. (2020) showed an increase in KKM of students in class X MIPA 1 at SMA Negeri 2 Garut on the material of two-variable inequality systems using the DL model. This is also supported by the ES value of 7.27 which shows very high criteria in the influence of the model on students' mathematical communication skills.

The fourth article Habibi, at. al. (2019) showed an increase in the KKM of class X MAN 2 Subang students who applied the DL model with the help of *hypnoteaching* in learning mathematics. The ES obtained from this study has a very large category with a value of 1.3. This shows the enormous influence of the DL model to improve mathematical communication skills.

The fifth article Jarwan (2018) shows a significant effect on student KKM in DL model learning for SMP Negeri 1 Pitumpia class VII students. This is also supported by the magnitude of the ES category which is valued at 2.71 which indicates that the model has a significant impact on increasing students' KKM.

The research results in the sixth article (Pasaribu, 2017) show that the increase in KKM of students in class VII MTsN 1 Padangsidimpuan in learning using the DL model is higher than students who are taught by direct learning. The ES obtained from this study was 1.6 with a very large category. This value illustrates that the application of the DL model is very effective in increasing students' KKM.

The results of research on the seventh article Dina, at. al. (2019) show that the improvement of students' KKM with the DL model is better than the improvement of students' mathematical communication skills with conventional learning. However, the application of the DL model to the KKM of VIII grade students of SMPN 2 Sigli is still in the medium category. This is indicated by the ES value which is only 0.47.

The research results in the eighth article (S., at. al., 2019) showed that students of class VIII F SMPN 1 Natar obtained an increase in KKM after using the DL model in learning. The results showed an ES value of 3.25 which was included in the very high category. The very high ES value is in line with the results of the findings regarding the improvement of students' KKM.

The research results in the ninth article Ariesta & Awalludin (2021) show an increase in KKM for students in class VIII A SMPN 184 Jakarta in DL model learning assisted by LKPD with statistical material and opportunities. The results of this study are supported by an ES value of 1.046 in the very large category.

The research results in the tenth article also showed an increase in the KKM of students in class VIII SMPN 1 Cihampelas who used the DL model more significantly than students who used the conventional model. This effect is again supported by the magnitude of the ES category which is worth 1.33. This finding proves that the application of the DL model is effective in improving student performance.

CONCLUSIONS

Based on the analysis of the ten articles, it was found that the DL model generally has a very large influence on students' ES. Nine of the ten articles showed a very large *ES*

category, while one article showed a medium category. This means that the application of the DL model is effective in encouraging students' active involvement in the learning process, which significantly contributes to the development of mathematical thinking and communication skills. Therefore, this model is recommended to be used more widely in mathematics learning.

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