M A T H L I N E
JURNAL MATEMATIKA DAN PENDIDIKAN MATEMATIKA
ISSN 2502-5872 (Print)
ISSN 2622-3627 (Elektronik)

Volume 9 Nomor 2, May 2024, 331-346

META ANALYSIS: THE EFFECT OF THE GEOGEBRA APPLET-ASSISTED DISCOVERY LEARNING MODEL ON STUDENTS' MATHEMATICAL PROBLEM SOLVING ABILITY IN GEOMETRY MATERIAL

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ABSTRACT
Good mathematical problem solving ability are important for students because they are the goals and principles in learning mathematics. However, various studies, both national and international, state that students' mathematical problem solving abilities in Indonesia are still low. The Geogebra-assisted discovery learning model is an innovation that can be used to improve students' mathematical problem solving abilities. This research aims to analyze the influence of the Geogebra-assisted discovery learning model on students' mathematical problem solving abilities in geometry learning. The research method used is meta analysis. The articles analyzed are articles sourced from Scopus, ScienceDirect and Google Scholar with a period of 2013-2023. Of the 10 articles analyzed, 3 of them studied groups of middle school students, 4 groups of high school students, and 3 students. The results showed that 8 articles had a large effect size, 1 article was a medium size, and 1 article was a small size. The results of the Independent Sample t-test obtained tcount of 11.59 and ttable of 1.96. So it can be concluded that the discovery learning model assisted by Geogebra has an effect on students' mathematical problem solving abilities in geometry learning. Through the discovery model, students discover their own concepts and solve the problems. Geogebra is important for illustrating geometric problems. Future research can also analyze the extent of the influence of the Discovery Learning model assisted by Geogebra on students' mathematical problem solving abilities in terms of various other variables both from within the students and from the surrounding environment.
Keywords: Discovery Learning, Geogebra Applet, Mathematical Problem Solving

How to Cite: Noverianto, B., Agoestanto, A., Dewi, N. R., & Mariani, S. (2024). Meta Analysis: The Effect of The Geogebra Applet-Assisted Discovery Learning Model on Students' Mathematical Problem Solving Ability in Geometry Material. *Mathline: Jurnal Matematika dan Pendidikan Matematika*, *9*(2), 331-346. http://doi.org/10.31943/mathline.v9i2.604

PRELIMINARY

Mathematics is a subject taught to students at both elementary, middle and high school levels. According to Minister of Education and Culture Regulation Number 22 of 2016, mathematical problem solving ability is one of the goals of mathematics learning. Apart from that, mathematical problem solving abilities are also in accordance with the principles of mathematics learning according to NCTM (National Council of Teachers of Mathematics) (NCTM, 2000). The two statements above indicate that mathematical problem solving abilities are important in learning mathematics.Yuhani et al. (2018) defines problem

solving as students' ability to solve non-routine problems that are usually related to real life. Non-routine problems allow students to use different solutions and strategies in the problem-solving process (Apostol, 2017). According to Polya (1973), the student's process in solving problems can go through four stages, namely: (1) understanding the problem, (2) formulating a problem solving plan, (3) carrying out a problem solving plan, and (4) checking the results of problem solving again.

Problem solving ability is one of the indicators of the PISA (Program for International Student Assessment) international study assessment. Based on 2022 PISA results data, students in Indonesia in mathematics only got a score of 366 and were ranked 65 out of 81 countries (OECD, 2023). The data is in accordance with the analysis Sulistyaningsih et al., (2016) in his research which states that the average student's mathematical problem solving ability is at level 1 and only 10% of 24 students can reach level 6 so it can be said that students' mathematical problem solving abilities are still at a low level. In their research, Sulistyaningsih et al. also stated that students with high problem solving abilities were 11.77% and students with low problem solving abilities were 52.94%.

The lack of students' mathematical problem solving abilities in geometry material is caused by various things.Widiastuti & Nindiasari (2022) states that the lack of students' mathematical problem solving abilities is caused by various things such as students not communicating and interacting in class, the use of strategies, methods and learning models is still not implemented in the learning process, and the use of media is still underutilized. Indrayany & Lestari (2019), And Yeni (2011) in his research, The lack of appropriate geometry learning media to visualize objects is one of the causes of students' low ability to solve mathematical problems. Based on this, appropriate innovation is needed to develop students' mathematical problem solving abilities, especially in learning geometry.

Discovery learning is an appropriate learning model that can be used and is appropriate to these problems. Discovery learning can organize learning methods that guide students to discover a concept and do not present the concept directly to students (Fajri, 2019). These models and approaches must be accompanied by appropriate geometry learning media. Geogebra applet is an interactive worksheet that students can access online via the Geogebra application or website (Destini et al., 2022).This media facilitates students to carry out a series of activities that encourage student discovery of a mathematical concept. By discovering concepts in students, their understanding of material will last longer than just memorizing.Apriani et al. (2020). In his research, it was revealed that the GeoGebra-assisted discovery learning model was effectively used in the student problem solving process

because the steps in discovery learning made students active in constructing knowledge and solving problems through GeoGebra interactive media. The discovery learning model encourages students to actively discover the concepts being taught for themselves so that they can understand the material completely and in the long term (Murni et al., 2022). According to Mone & Abi (2020), the steps of the Geogebra-assisted discovery learning model for solving problems consist of the following 5 stages.

Table 1. Steps of Geogebra Assisted Discovery Learning Model

Learning Steps	Description	Problem Solving Process
Stimulation	Students are faced with issues/problems that raise questions, the teacher does not provide direct generalizations so students are asked to carry out investigations independently. Activities begin with asking questions, looking for references, learning how to use geogebra, and other activities as preparation for solving problems.	Understanding the problem
Problem statement	The teacher asks students to identify the problem to be solved, then students create a problem formulation and hypothesis related to the problem to be solved.	Understanding the problem,and devising a plan
Data collection	Students carry out activities to collect useful information, carry out observations, experiments, or read literature from various sources such as books, research journals, trusted websites, and other sources.	Devising a plan
Data processing	Students carry out activities to process data and information that has been obtained through interviews, observations and so on with the help of Geogebra software. This stage functions as concept formation and generalization, so that students will gain new concepts or knowledge from proof and searches carried out logically and systematically.	Carrying out the plan
Verification	Students together carefully examine the results of the evidence and work carried out through presentation of	Looking back

Learning Steps	Description	Problem Solving Process
	results and link them to the initial hypothesis that has been made.	
Generalization	Students draw conclusions from the verification results so that they can be used as general principles that can be used to solve similar problems.	Looking back

Based on this, the aim of this article is to determine the influence of the discovery learning model assisted by Geogebra applet media on students' mathematical problem solving abilities in geometry learning. With this aim, the problem of this research is whether the discovery learning model assisted by Geogebra applet has an effect on the development of students' mathematical problem solving abilities. This is done by studying in depth and sharing previous research.

METHODS

This research uses a meta-analysis method by reviewing several articles in national and international journals. Meta analysis is a form of synthesis of several studies that focuses on the results of the research process found (Kristiana, Aliksia, Utami & Kuneni, 2016). Data collection in this research was carried out by searching for articles on the internet related to the use of discovery learning strategies assisted by Geogebra applets in solving student problems in the last ten years (2013-2023). The data collected comes from a combination of Scopus, ScienceDirect and Google Scholar sources. After searching 25 articles, only 10 articles were found that met the criteria to be used as research samples. The research procedures carried out refer to the meta-analysis stage Glass et al. (1983), Supriyadi et al., (2023) namely: (1) determining the research domain to be summarized, (2) choosing the type of publications to be collected, (3) collecting research results, (4) recording research data, (5) calculating the effect size of each research result, (6) carrying out independent sample t tests, and (7) calculate the degree of heterogeneity of the data taken.

Effect size calculated to find the magnitude of the influence resulting from the application of the discovery learning model assisted by the Geogebra applet. The following is the formula for calculating effect size using the Cohan's d formula (Becker, 1999). The calculation results Effect size interpreted using the following classification:

Table 2. Interpretation of Effect Size

Effect size	Interpretation
$0{,}2 \leq A \leq 0{,}5$	Small
$0{,}5 \leq A \leq 1$	Medium
$A \geq 1$	Large

Then the researcher compared the average results of the experimental and control classes using an independent sample t-test to determine the difference between the average of control class students and the average of female class students. The next step is to determine the effect of the model used in this meta-analysis research using the t test.

RESULT AND DISCUSSION

After collecting data from 25 articles, 10 articles were found from accredited national and international journals which discussed 3 complete keywords, namely the discovery learning model, geogebra, and mathematical problem solving abilities, so only these 10 articles could be used to analyze the Discovery Learning model with the help of the Geogebra applet on students' problem solving abilities used in each article, the following results were obtained:

Table 3. Results of article analysis

Title	Results	Author	Source
GeoGebra Assist Discovery Learning Model for Problem Solving Ability and Attitude toward Mathematics	The results of the research show that using GeoGebra in discovery learning can improve problem-solving abilities and improve student attitudes. Geogebra can present problems that attract interest and make it easier for students to identify problems.	V. Murni et al., 2017	*Journal of Physics: Conference Series*
The discovery teaching of the problem of finding the shortest distance with the help of Geogebra	It was found that students felt very interested in the discovery method. Students show joy and enthusiasm in learning to find the shortest distance with GeoGebra software assistance. The assessment results show that students make more progress when	Nguyen, 2021	*Educational Research and Reviews*

Title	Results	Author	Source
software in Vietnam	applying GeoGebra in teaching compared to conventional teaching methods.		
Model Discovery learning Berbantuan Geogebra Untuk Meningkatkan Kemampuan Pemecahan Masalah	The results of research in applying the Geogebra-assisted Discovery Learning model show that there is an increase in problem-solving abilities after the learning process occurs, problem-solving abilities are complete and the problem-solving abilities of students taught with the Geogebra-assisted Discovery learning model are better than students taught with the conventional model.	Mone & Abi, 2017	*Paedagogia, Jurnal Penelitian Pendidikan*
Integration of GeoGebra in Teaching and Learning Geometric Transformations at Ordinary Level in Zimbabwe	The results of this study show that although conventional methods have a positive impact on students' performance, the use of geogebra further improves their performance in transformation geometry. Teachers must use virtual manipulative media to carry out mathematics teaching because it will increase mastery and retention of concepts as reflected in learning.	Mukamba & Makamure , 2020	*Contemporary Mathematics and Science Education*
Information and Communication Technologies to Improve Problem Solving and Self-Efficacy: Exploring Geometry Learning	The results of the research show that problem solving and self-efficacy of students who use Geogebra-assisted discovery learning are better than those using conventional learning. It can be concluded that the dynamic Geogebra mathematics software is effective for	Mukhtar et al., 2021	*International Journal of STEM Education for Sustainability*

Title	Results	Author	Source
Using Dynamic Mathematics Software Geogebra	increasing problem solving and self-efficacy.		
Efektivitas Media dalam Pembelajaran Guided Discovey Ditinjau dari Kemampuan Pemecahan Masalah dan Sikap	The results of the research show that geogebra-assisted learning is effective in terms of problem-solving abilities and attitudes towards mathematics, while learning aided by teaching aids is not effective in terms of problem-solving abilities but is effective in terms of attitudes towards mathematics.	Kusumaningrum, 2017	*Jurnal Pedagogi Matematika*
The application of discovery learning as an effort to improve mathematical problem solving skills	From the results of the analysis it can be concluded that students who received treatment with the Discovery Learning model obtained better learning outcomes than classes that did not receive discovery learning treatment.	Qurohman & Romadhon, 2023	*International Journal of Trends in Mathematics Education Research*
Dynamic technology tool to support active learning in mathematics	By implementing new or existing innovative practices such as geogebra, especially in mathematics teaching also increases student engagement in the respective modules. The results show that students are more interested in discovery learning with geogebra than in long learning.	Bhatti et al., 2017	*International Symposium on Educational Technology*
Teaching Geometry According to the Discovery Method with GeoGebra	The research results state that learning using geogebra media can help the teaching process to explore forms of transformation in planes and spaces	Tran & Nguyen, 2020	*International Conference on Research of Educational Administration*

Title	Results	Author	Source
Software: A case study in Vietnam	according to the examples and illustrations provided.		*and Management*
Implementation of Space Geometry Learning Using Geogebra to Improve Problem Solving Skills	The results show that Geogebra-based Spatial Geometry learning can improve problem-solving abilities. In the experimental group, problem solving skills increased in the high category, while in the control group increased problem solving abilities in the medium category.	Pamungkas & Nugroho, 2020	*Jurnal Matematika Dan Pembelajaran*

Of the 10 articles analyzed, there is division of student levels as follows.

Table 4. School Level of Students from Analyzed Articles

School Level	Many articles
Junior high school	3
Senior High School	4
College	3

From the results of the data above, an effect size calculation was carried out to measure the extent to which the discovery learning model assisted by the Geogebra applet was able to solve student problems. The results of the effect size calculation are as follows:

Table 5. Effect Size Analyzed

N		Average		Standard deviation		elementary school Combined	Effect Size	Note
Control	Experiment	Control	Experiment	Control	Experiment			
30	30	29.6	39.03	5.7	7.94	3.9	2.41	Large
25	24	73.4	79.6	11.2	9.7	4.2	1.47	Large
20	20	57.26	72.55	10.48	10.48	10.48	1.45	Large
26	28	18.42	27.4	4.39	5.74	2.8	3,2	Large
36	36	39.34	50.3	5.01	6.98	3.43	3.19	Large
24	24	79.3	87.22	7.03	9.1	8.13	0.97	Large
40	38	63.25	64.08	9.52	8.98	2.69	0.3	Small
48	30	52.14	62.81	16.24	12.33	3.24	3.28	Large
37	38	58	65.9	16.2	14.8	15.7	0.5	Medium
35	36	84.06	93.3	5.7	8.2	7.18	1.28	Large

From the data above, look that 8 of the previous studies showed effect sizes in the large category, 2 studies were in the medium category, and the rest were in the small category. Then from this data combined standard deviation of the two groups can be calculated using the formula. After going through the calculation process, we obtained a value of 12.10 as the combined standard deviation of the control group and a value of 10.82 as the combined standard deviation of the experimental group, as well as a value of 11.43 as the overall standard deviation.

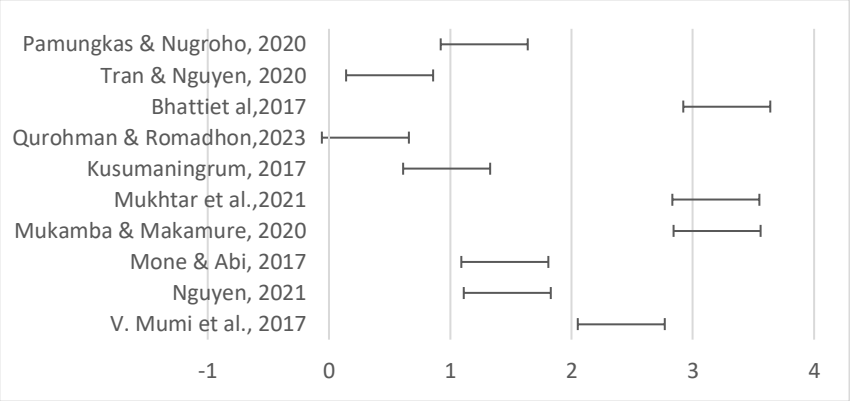

Figure 1. Effect Size of The Article

After that, an independent sample t test was carried out to determine any differences between the experimental group where students were treated with the discovery learning model assisted by Geogebra applet and the control group with the traditional model. The statistical hypothesis is as follows.

$H_0: \mu_1 \leq \mu_2$ (The average problem solving ability of students using the discovery learning model assisted by Geogebra is less than or equal to the average problem solving ability of students in learning conventional)

$H_1: \mu_1 > \mu_2$ (The average problem solving ability of students using the discovery learning model assisted by Geogebra is more than the average problem solving ability of students in learning conventional)

Based on the calculation results, the control group's average value was 54.63 and the experimental group's average value was 63.38. After carrying out the t test calculation, the calculated t value is obtained 11,59 while t table 1.96. Based on this, t count > t table so that H_0 is rejected. So it can be concluded that the average problem solving ability of students who are treated with the Geogebra-assisted discovery learning model is better than the average problem solving ability of students who are treated conventional model.

Next, a chi-square test was carried out to determine the level of heterogeneity of the data taken. The criteria used are if p > 0.05 then heterogeneity is low/moderate, and if p <

0.05 then heterogeneity is high. Based on the Chi-square test, the p value is 0.03, it is clear that it is less than 0.05 so the data has high diversity or heterogeneity.

Table 6. Heterogeneity Test

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	20.000[a]	19	.0395
Likelihood Ratio	27.726	19	.089
Linear-by-Linear Association	.870	1	.351
N of Valid Cases	20		

Jana & Fahmawati (2020) stated that learning steps using the discovery learning model have been proven to support increasing students' problem solving abilities. At the collection and data processing stage, students are directed to understand the problem and design a solution strategy, while at the verification and generalization stage students can implement and recheck the answers obtained. The discovery learning model also supports organizing students' learning methods to discover their own concepts, rather than presenting concepts in finished form to students (Fajri, 2019). Through this discovery learning model, students not only understand mathematical concepts theoretically, but they also develop the critical and analytical thinking skills needed to solve problems. They are invited to ask questions, propose hypotheses, and try various approaches to find effective solutions.

The discovery learning model assisted by Geogebra has become a popular approach in improving students' problem solving abilities in the field of mathematics. By harnessing the power of technology for mathematical visualization, students have the opportunity to more deeply understand the concepts underlying mathematical problems. One of the main advantages of this model is that students can learn through direct and interactive experiences, allowing them to be actively involved in the learning process. In the Geogebra context, students can actively explore mathematical concepts by creating models, manipulating objects, and observing interactions between various variables. For example, they can visualize the relationship between a linear function and its graph, or explore the geometric properties of a plane shape by changing certain parameters.

Using Geogebra also allows students to access material visually, which can help students with a visual learning style to understand concepts better. They can see graphical representations of mathematical concepts, which can help them build a deeper and more intuitive understanding. In addition, this learning model encourages collaboration between students. They can work together in groups to explore math concepts, share ideas, and

provide feedback to each other. This creates a dynamic learning environment where students can learn from each other and expand their understanding discussion and collaboration.

The Geogebra applet here supports discovery learning, just like the LKPD which contains a series of activities that encourage students' understanding through discovery activities and application of concepts in solving geometric problems (Lestari, 2018). The differences in learning processes or steps that occur cause the results of mathematical problem solving abilities between the two groups of students to be different. (Murni et al., 2017). The learning steps using the discovery learning model begin with illustrating the problem through geogebra. Students then make observations related to the problem presented. Next, the teacher gives questions to encourage students to ask what they will do. This aims to make students active in learning so that they can identify and design appropriate strategies in solving problems. Joyce et al. (2013) in his research stated that in this case geogebra carries out its function as a media needed in the learning process, namely making it easier for students to learn, assist teachers in presenting material, provide spatial illustrations for students, make students focus, and increase student motivation in learning.

The application of Geogebra in learning also prepares students to face more complex mathematical challenges in the future (Osypova & Tatochenko, 2021). They become familiar with the use of technology in a mathematical context and develop computing and problem-solving skills that are essential for success in an increasingly connected and technology-driven world. It is important to note that the discovery learning model assisted by Geogebra is not a replacement for traditional learning, but is an approach that can complement existing learning methods. Shadaan (2013) in his research stated that this allows students to have more varied and interesting learning experiences, which can motivate them to be more actively involved in the learning process. In addition, this model can be adapted to various student proficiency levels and learning styles. Teachers can provide guidance and direction that suits individual student needs, so that each student can learn at a level of difficulty appropriate to their abilities.

Thus, the discovery learning model assisted by Geogebra is an effective approach in improving students' problem solving abilities in the field of mathematics. Through active exploration, collaboration, and use of technology, students can deepen their understanding of mathematical concepts and develop the skills necessary to become intelligent and creative problem solvers. Geogebra-assisted discovery learning allows students to experience the process of discovering mathematical concepts independently. By using Geogebra, students can explore mathematical concepts by viewing graphic visualizations and conducting direct

experiments. Using Geogebra in discovery learning helps students understand the relationship between mathematical concepts visually and conceptually (Nurzannah et al., 2021). This model provides opportunities for students to develop mathematical problem solving ability in a more active and in-depth way.

The use of technology in learning mathematics with Geogebra helps students become more skilled in utilizing technology in problem solving. This model provides a fun and interesting learning experience for students, increasing their motivation to learn mathematics. By combining visual, interactive and exploratory aspects, Geogebra-assisted discovery learning creates a learning environment that stimulates and supports holistic student development. Students not only understand mathematical concepts in the abstract, but they also see how these concepts apply in real-world contexts (Lavicza et al., 2020). Thus, this model not only improves mathematical problem solving abilities, but also broadens students' understanding of the role of mathematics in everyday life. Through structured problem solving and reflection on their learning experiences, students can develop their metacognitive abilities. Geogebra-assisted discovery learning promotes lifelong learning, as students are given the opportunity to continue exploring and deepening their understanding of mathematics even after leaving the classroom.

This model is suitable for various learning styles and student proficiency levels, because it allows for differentiation in learning. With Geogebra, teachers can become learning facilitators who guide students through the discovery process, rather than simply conveying information (Mandailina, 2024). Geogebra-assisted discovery learning strengthens fundamental mathematical concepts and prepares students to understand more complex material in the future. This model emphasizes the importance of exploration, mistakes, and learning from experience as an integral part of the learning process. Students are given the freedom to take initiative in their learning, which increases their sense of responsibility and autonomy. By participating in discovery learning assisted by Geogebra, students not only become passive consumers of information, but also become active producers of knowledge. Learning through Geogebra stimulates students' imagination and creativity, as they are faced with the challenge of finding unique solutions mathematical.

Students learn to deal with uncertainty and ambiguity in problem solving, which are valuable skills in everyday life and future careers. This model supports a constructivist approach to learning, where knowledge is built through active interactions between students and learning material. By enabling students to explore mathematical concepts in depth, Geogebra-assisted discovery learning reduces the tendency to rely solely on memorization

and mechanical reasoning. Students learn to become mathematical researchers in a safe and structured environment, where they can experiment without fear of making mistakes. Through reflection on their learning experiences, students can develop a deeper understanding of mathematical thinking processes and strategies Apart from that, Geogebra helps teachers in teaching mathematics, such as checking students' answers, creating various new problem creations that students can work on, and providing good interaction between the two.(Tran et al., 2014). With these various benefits, Geogebra can of course be used as an appropriate learning medium to support mathematics learning, especially in terms of developing problem solving for students.

CONCLUSION

From the results and discussion, a conclusion can be drawn that students who were treated using the Discovery learning model and Geogebra applet learning media had better problem solving abilities compared to students who were treated using the conventional learning model. The steps in the Discovery Learning model correspond to the stages of problem solving for students. Meanwhile, the Geogebra applet acts as a learning medium in the form of a LKPD which can be easily accessed by students via the Geogebra website. The Geogebra applet provides interactive learning, supports students' visualization in understanding geometric objects, provides questions that provoke students to find concepts in solving problems, and supports problem solving for students through guided search stages. The implication of this research is that the Geogebra-assisted discovery learning model has an effect on increasing students' problem solving abilities so that it can be used in learning mathematics, especially geometry, at both junior and senior high school levels.

The recommendation from this meta-analysis research is that further research needs to be carried out to implement the Discovery Learning innovation model with the help of the Geogebra applet in solving student problems so that the advantages and disadvantages of this innovation are known. Researchers recommend that the use of Geogebra be adjusted to students' needs and learning styles. Further research could also examine the extent to which this innovation can be used in other mathematical topics.

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