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Meta-analysis of TPACK-based Discovery Learning Model on Learning Outcomes in Elementary School Students

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Abstract

This study aims to determine the effect of TPACK-based discovery learning model on the learning outcomes of elementary school students. The source of data in this study comes from an analysis of 15 national journals published in 2022-2024. The process of data retrieval through the databases of google scholar, ScienceDirect and ERIC Journal. Data selection using PRISMA method in 2020. The inclusion criteria in this study are that the research must be experimental methods or quasi-experiments; research sample of elementary school students; research should be related to TPACK-based dsicovery learning models on student learning outcomes; learning materials related to mathematics and Indonesian; journals must be indexed by Science Technology Index (SINTA) and Garuda; and a sample size of > 20 students. Data analysis in this study is quantitative analysis by calculating the value of effect size assisted by JSAP application Version 0.8.5. The results concluded that the TPACK-based inquiry model had a significant influence on student learning outcomes with rES = 1,114; P < 0.001. This finding has a positive impact on PGSD teachers to implement this model in the learning process.

Keywords: Discovery Learning Model; TPACK; Learning Outcomes; Meta-analysis

Introduction

Primary education plays an important role in building a foundation of learning for students. In the early stages of education, students learn the basics of science and skills that will become the foundation for their future abilities. Elementary education helps students build balanced study habits, improve critical thinking skills, and develop effective communication skills. Thus, basic education becomes a solid foundation for the future progress of students. Elementary education also allows students to develop balanced study habits, including critical thinking, analysis, and synthesis skills. By developing these skills, students can solve problems, complete tasks, and develop innovative ideas. Primary education also helps students build confidence and motivation to learn, so they can continue to improve their abilities in the future. Therefore, basic education is essential in building a strong learning foundation for students (Jones, 2016) (Bolat, 2023; Yep. Asriadi et al.,

2023) (Daniel et al., 2022; Winarni et al., 2020) (Sun et al., 2020) (Akihary et al., 2023; Öztürk, 2023)

Furthermore, learning outcomes play an important role in measuring the effectiveness of the learning process. Learning outcomes can be measured through a variety of means, such as performance appraisals, tests, and projects. By measuring learning outcomes, teachers can find out how far students have reached learning goals and whether the learning process used is effective. Learning outcomes also help teachers adjust learning strategies and improve the quality of learning. Thus, learning outcomes become an important indicator in increasing the effectiveness of the learning process. Learning outcomes also allow teachers to know students' weaknesses and strengths, so they can provide more specific and effective assistance. Thus, learning outcomes help teachers in improving students' abilities and improving the quality of education. In addition, learning outcomes also help students in measuring their own abilities and increase motivation to learn. Therefore, learning outcomes are very important in measuring the effectiveness of the learning process and improving the quality of education. One learning model that can improve student outcomes is the discovery learning model. (Usman et al., 2022) (Kisworo, 2016; Lekhak, 2023) (Harris & Clayton, 2019) (Usman et al., 2022)

Discovery Learning is a student-centered learning model, where teachers provide opportunities for students to discover and explore their own knowledge. In this model, students are expected to actively seek and discover information, as well as generalize new knowledge with previously known. The teacher only acts as a facilitator who provides guidance and encouragement, so that students can become more independent in their learning process. Using the Discovery Learning model, students can improve learning outcomes, critical thinking skills and higher-order thinking skills. They can also develop analytical, synthesis, and evaluation skills, as well as increase motivation and activeness in learning activities. In addition, this model can also help students develop communication skills and cooperation skills, as well as improve learning outcomes significantly. The discovery learning model can be linked to the TPACK approach. (Turmuzi & Lu'luilmaknun, 2023; Wardono et al., 2020) (Öztürk et al., 2022) (Simamora et al., 2018)

TPACK (Technological Pedagogical Content Knowledge) is a framework that integrates three types of knowledge essential for teachers for effective teaching in the digital age: technological knowledge, pedagogical knowledge, and content knowledge Within the TPACK framework, educators not only need to understand the technology and

how to use it, but also need to know how to integrate the technology into the in effective pedagogical practice as well as the content taught. (Bwalya et al., 2023).

The relevance of TPACK to Discovery Learning is very significant because Discovery Learning is a learning approach that emphasizes students to learn through discovery and exploration. Discovery Learning requires students to be active in finding information, testing hypotheses, and finding solutions to problems faced, where technology can be a very powerful tool in the learning process. However, there are several challenges in its implementation, such as teacher readiness in mastering technology, limited technological facilities in schools, and variations in student acceptance and response to this learning method. This study seeks to dig deeper into the effectiveness of the model in improving student learning outcomes, as well as identifying supporting and inhibiting factors that influence the success of its implementation in the elementary school environment. Therefore, there is a need for a meta-analysis to determine the effectiveness of the TPACK-based discovery learning model to determine the effectiveness of the model (Helsa et al., 2023; Alamri & Awjah, 2023) (Fazilla et al., 2023) (Chaidam &; Poonputta, 2022; Alamri & Awjah, 2023)

This meta-analysis aims to identify and analyze problems in the application of this learning model. TPACK (Technological Pedagogical Content Knowledge) based Discovery Learning integrates technology with pedagogical knowledge and content to improve the quality of learning in elementary school students.

Research Methods

This research is a type of meta-analysis research. Meta-analysis research is a type of research that collects and analyzes previous research quantitatively to get an in-depth conclusion. The source of data in this study comes from an analysis of 15 national journals published in 2022-2024. The process of data retrieval through the databases of google scholar, ScienceDirect and ERIC Journal. Data selection using PRISMA method in 2020. The inclusion criteria in this study are that the research must be experimental methods or quasi-experiments; research sample of elementary school students; research should be related to TPACK-based dsicovery learning models on student learning outcomes; learning materials related to mathematics and Indonesian; journals must be indexed by Science Technology Index (SINTA) and Garuda; and a sample size of > 20 students. Data analysis in this study is quantitative analysis by calculating the value of effect size assisted by JSAP application Version 0.8.5. Furthermore, the criteria for effect size in research can be seen

in Table 1. (Çevik &; Bakioğlu, 2022; Turmuzi &; Lu'luilmaknun, 2023; Zulkifli et al., 2022)

Table 1. Effect Size Value Criteria

Effect Size	Effect Size Criteria
0.00≤ ES≤ 0.20	Low
0.20≤ ES≤ 0.80	Keep
ES≥ 0.80	Tall

Source: (Ichsan et al., 2023)

Results and Discussion

Result

From the results of data searches through Google Scholar databases, ScienceDirect and ERIC obtained 126 journals related to TPACK-based discovery learning models on student learning outcomes. However, the journals were selected based on predetermined inclusion criteria, so 15 suitable journals were obtained. The process of selecting data sources through the PRISMA method can be seen in Figure 1.

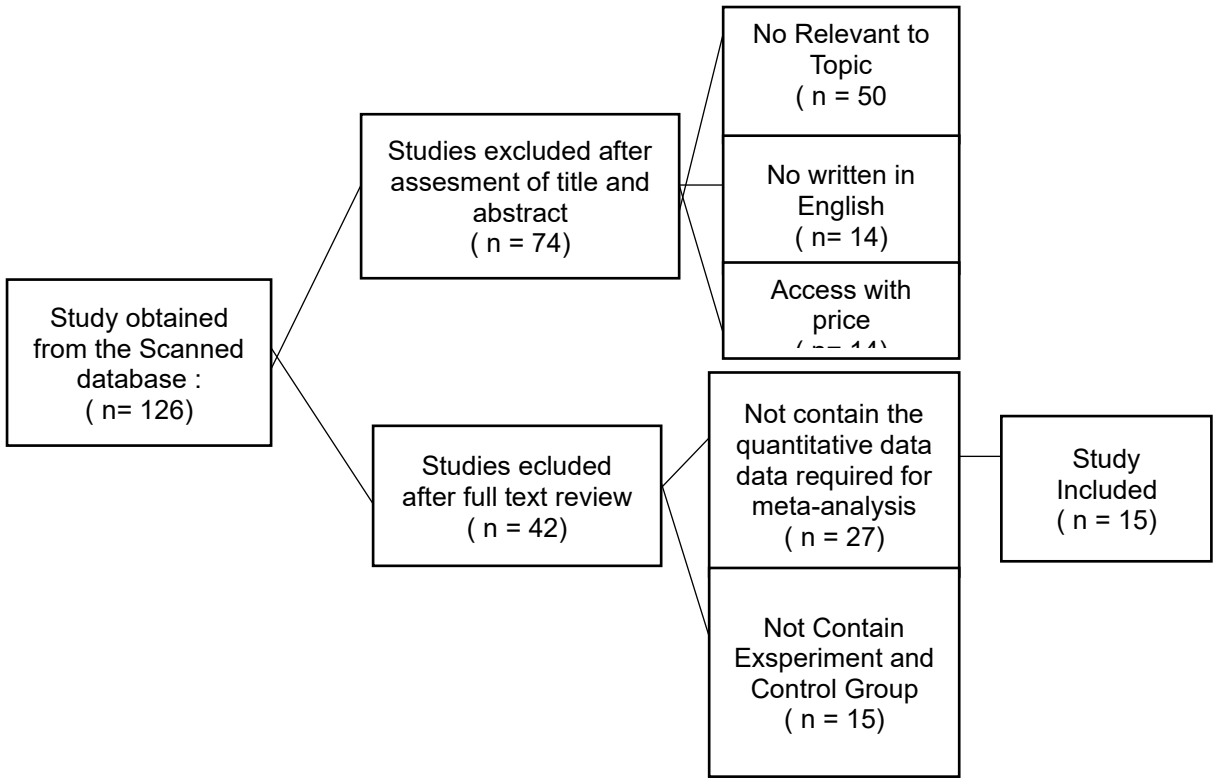

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Figure 1. Data Source Selection Process with PRISMA Method

Next, conduct a heterogeneity test of 15 *effect sizes* analyzed using a random effect model that can be seen in Table 2.

Table 2. Effect Size Heterogeneity Test Results

Type	n	Effect Size	Z	Standard Error	95% Confidence Interval		Q	P
					Lower	Upper		
Fixed	15	0.617	5.08	0.008	0.417	0.782	51.043	0.00
Random	15	0.714	6.247	0.197	0.526	0.915		

Based on Table 2, the value of *the fixed effect model* is 0.617 and the random effect model is 0.714. The results of the heterogeneity test explained that the 15 effect sizes analyzed were heterogeneously distributed with a value of Q = 51,043; p < 0.00. Furthermore, analyzing the publicity bias with *the funnel plot* and *testing Egger's* Hasi checking publication bias through the funnel plot can be seen in figure 2.

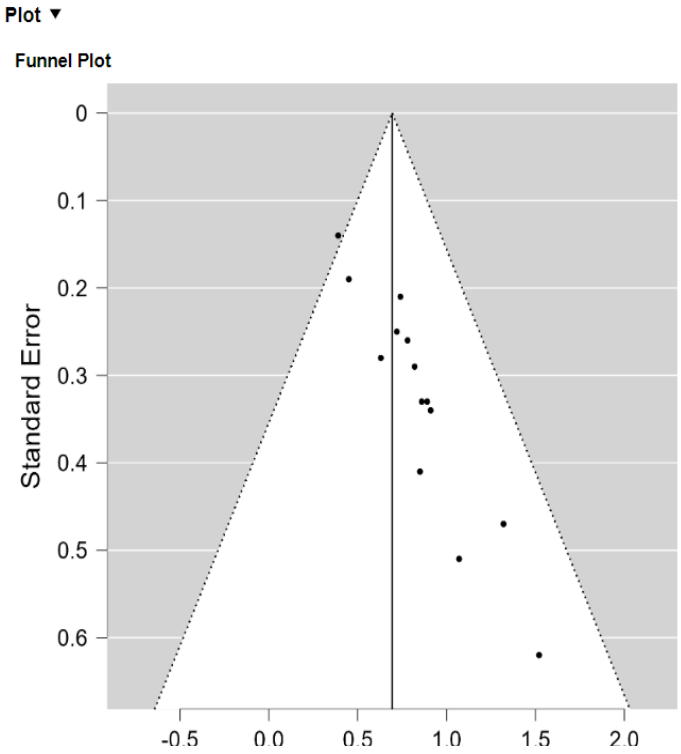

Figure 2. Standard Funnel Plot Error

Based on figure 2, funnel plot analysis describes the effect size analyzed whether symmetric or asymmetric on the curve of the funnle plot. Therefore, it is necessary to perform the Egger's test which can be seen in Table 3.

Table 3. Egger's Test Results

	z	p
Sei	2.182	< 0.001

Table 3, Egger's test results show z = 2.12 and p < 0.001. This finding shows that the funnel plot curve is simestris shaped and the 15 effect sizes analyzed are resistant to publication bias. The next step is to conduct a hypothesis test to determine the effect of the TPACK-based discovery learning model on the learning outcomes of elementary school students through summary effect size analysis which can be seen in Table 4.

Table 4. Summary Effect Size

	Estimate	**Standard Error**	**z**	**95 % CI**		**p**
				Lower	Upper	
Intercept	1.12	0.271	7.082	0.615	9.167	< 0.001

Based on Table 4, the summary effect size value is 1.12 with a standard error of 0.271. This finding explains that the TPACK-based discovery learning model has a significant influence on the learning outcomes of elementary school students with a high effect size category (res = 1.12; z = 7.082; p < 0.001). TPACK-based discovery learning model has a positive influence on students compared to conventional learning models.

Discussion

Based on the results of the study, the application of the TPACK-based discovery learning model has a positive influence on student learning outcomes with an average effect size value of = 1.12 with a high effect size category. The results of this study are in line with (Pane et al., 2020) the application of an effective discovery learning model to improve student learning outcomes. This finding is supported by the discovery learning model encourages students to be more active and independent so that students improve student learning outcomes in learning activities. (Azizah &; Fajeriah, 2021)

Furthermore, the TPACK-based Discovery Learning Model (*Technological, Pedagogical, Content Knowledge*) is a learning model developed to improve the creative thinking ability and cognition of elementary school students. In this model, teachers use technology, pedagogic competence, and subject content to develop students' skills in critical thinking and students' creative learning. TPACK-based learning, teachers use various strategies to improve students' abilities. This strategy includes the use of technology, simulations, and interactive games to build students' knowledge and skills.

Thus, students can think critically and creatively in solving problems. (Mustikaningrum &; Mediatati, 2021) Sholihah &; Rusyana, 2023) (Helsa et al., 2023)

TPACK-based Discovery Learning model, teachers must prepare well and anticipate questions that may arise. Teachers must also be able to provide correct answers or guidelines to assist students in thinking critically and creatively. In addition, teachers must prepare well and use interactive strategies to improve student learning outcomes. (Alamri &; Awjah, 2023)

Conclusion

From the results of this meta-analysis study, it can be concluded that the TPACK-based inquiry model has a significant influence on student learning outcomes with rES = 1,114; P < 0.001. This finding has a positive impact on PGSD teachers to implement this model in the learning process. The use of TPACK-based Discovery Learning not only helps students understand the concepts of the lesson more deeply, but also increases their motivation and involvement in the learning process. This method encourages students to actively explore and discover new knowledge independently or in groups.

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