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THE EFFECT OF THE INTERNET OF THINGS INTEGRATED DISCOVERY LEARNING MODEL ON STUDENTS CRITICAL THINKING SKILLS

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Abstract

The purpose of this study was to determine the effect of the Internet of Things integrated discovery learning model on students' critical thinking skills. This study is a meta-analysis study. The data source comes from an analysis of 9 national and international journals. The process of tracing data sources through Google Scholar, Proquest, EBSCO, DOAJ, and ERIC databases. Data source selection technique through PRISMA method. The inclusion criteria in this study are research published in 2020-2023, SINTA and Scopus indexed research, research using experimental methods, and research must have a sample of 20 students. Data analysis in this study calculated the value of effect size, heterogeneity, summary effect size and publication bias with the help of JASP application. The results of this study concluded the average value of effect size of (ES = 1.06) high criteria. These findings explain that there is a significant influence of the Internet of Things integrated discovery learning model on students' critical thinking skills

Keywords: Discovery Learning, Internet of Things (IoT), Critical Thinking, Meta-analysis

Introduction

Critical thinking is a skill that students must master in facing the industrial revolution 4.0 (Elfira et al., 2023; Suharyat et al., 2023; Alsaleh, 2020). Critical thinking skills are important for students in forming a systematic and logical mindset (Rosa &; Pujiati, 201; Muthmainnah et al., 2022; Fradila et al., 2021; Fikriyatii et al., 2022). In addition, critical thinking skills help students solve a problem in life (Utomo et al., 2023;

Atwa et al., 2022). Critical thinking skills include Higher *Order Thinking Skills* that train students to be active and creative in learning (Kanmaz, 2022; Razak et al., 2021; Maison, 2022). Therefore, the learning process in schools must be directed to students to think critically.

But in fact, students' thinking skills in school are still relatively low (Ariyatun et al., 2020; Irhasyuarna et al., 2022). This can be seen in the learning process that is more teacher-centered (Suharyat et al., 2022; Zulyusri et al., 2022; Sofianora et al., 2023), so that learning becomes menoton. Learning processes that do not involve active students and teachers do not direct learning that stimulates students to think critically (Anggraini &; Nurtamam, 2016; Nurtamam et al., 2023; Sutoyo et al., 2023). Furthermore, the application of learning models and approaches does not lead students to higher-order thinking (Alomery, 2022; Hamdani et al., 2022). Not only that, the results of TIMSS research in 2015 showed that the level of critical thinking skills of Indonesian students was still low, only obtaining a score of 396, far from the international average score of 500 (Rahman et al., 2023; Luciana et al., 2023; Zulkifli et al., 2022; Putra et al., 2023). So, there needs to be a learning model that can support students' critical thinking skills in learning.

Discovery learning is one of the learning models that can help students think critically (Hariyanto et al., 2022; Chusni et al., 2022). The *discovery* learning model is one of the learning models that trains students to understand concepts and relationships through a reasoning process to draw a conclusion (Hasnan &; Fitria, 2020; Affandi et al., 2022; Ristanto et al., 2022; Maarif, 2016). The discovery learning model can help students be active and guide creative students in thinking (Halimah, 2021). Khofiyah et al., (2019) The discovery learning model trains students to find concepts in the learning process.

Furthermore, discovery learning models can be integrated with the *Internet of Things* (IoT). *Internet of Things* (IoT) is a process of utilizing technology to transfer information more indefinitely (Arsana, 2021; Paricherla et al., 2023; Now et al., 2022). *The Internet of Things* has enormous benefits for students to obtain information for learning resources. Jiwandono et al., (2021) *Internet of things* in encouraging the improvement of teacher competence in carrying out the learning process. So, with the integrated discovery learning model, the Internet of Things provides solutions in improving students' critical thinking skills.

Research in Indonesia (Widiadnyana et al., 2014; Rahmawati, 2015; Rahmayani et al., 2019; Martaida et al., 2017) The discovery learning model can improve students' understanding of concepts, learning outcomes and scientific attitudes so as to encourage students to think critically. Research from abroad (Balim, 2009; Gutiérrez et al., 2022) The *discovery* learning model has an influence on students' cognitive development in learning. The gap in research is that many studies related to discovery models have not found the effect of the size of the Internet of Things integrated discovery *learning* model on students' critical thinking skills. Therefore, the study aims

to determine the effect of the Internet of Things integrated discovery learning model on students' critical thinking skills.

Research Method

This research is a type of meta-analysis research. Meta-analysis research is a type of research collecting and analyzing data quantitatively with statistical analysis (Santosa et al., 2021; Ichsan et al., 2022; Qaim & Klu, 2014; Tamur &; Wijaya, 2021; Suryono et al., 2023). The meta-analysis study aims to determine the effect of the *size of the Internet of Things* (IoT) integrated learning discoveru learning model on students' critical thinking skills. The data source comes from an analysis of 9 national and international journals. The process of tracing data sources through Google Scholar, Proquest, EBSCO, DOAJ, and ERIC databases. Data source selection technique through PRISMA method. The inclusion criteria in this study are research published in 2020-2023, SINTA and Scopus indexed research, research using experimental methods, and research must have a sample of 20 students.

According to Borenstein et al., (2010) the steps in analytical research consist of 1) Formulating the problem to be studied; 2) collect data; 3) perform data encoding; 4) Data analysis and interpretation. Data analysis in this study calculated the value of effect size, heterogeneity, *summary effect size* and publication bias with the help of JASP application. The criteria for effect size values can be seen in Table 1.

Table 1. Effect Size Value Category

Effect Size	Category
0 ≤ ES ≤ 0.2	Low
0.2 ≤ ES ≤ 0.8	Medium
ES ≥ 0.8	High

Result and Discussion

From 240 studies that have been searched through Google Scholar, ProQuest, EBSCO, DOAJ, and ERIC databases, only 9 studies were obtained that met the inclusion criteria. Research that meets inclusion chiteria is analyzed based on the characteristics of journal code, year of publication, country, effect size and effect size criteria. The results of the analysis of research characteristics in are seen in Table 2.

Table 2. Research Analysis Results

Journal Code	Year of Publication	Country	Variable Bound	Effect Size	Criterion
AR1	2022	Indonesian	Critical Thinking	0.71	Medium

AR2	2022	India	Critical Thinking	0.56	Medium
AR3	2023	Indonesian	Critical Thinking	1.12	High
AR4	2021	India	Critical Thinking	2.06	High
AR5	2021	Turkish	Critical Thinking	1.09	High
AR6	2021	English	Critical Thinking	0.94	High
AR7	2020	China	Critical Thinking	0.75	medium
AR8	2023	Indonesian	Critical Thinking	0.98	High
AR9	2020	Indonesian	Critical Thinking	1.10	High
Average value of effect size				**1.06**	**High**

Based on Table 2. Research analysis based on characteristics where publications are published from 2020-2023, research from 5 countries, namely Indonesia, Turkey, India, the United Kingdom and China, three studies of effect size values ranged from 0.56 – 0.75 medium criteria and 6 effect size values of 0.94 – 2.06 high criteria. Furthermore, the average value of effect size is 1.06 high criteria. These results can be concluded that the Internet of Things integrated discovery learning model has a significant influence on students' critical thinking skills. Research (Chusni et al., 2022; Fadhil et al., 2018) The discovery learning model has an influence on students' critical thinking skills in the learning process. The *discovery* learning model integrated with the Internet of Things is able to train students to be more active, innovative and creative in learning (Noer, 2018; Mardi et al., 2021; Willner et al., 2020; Sopapradit &; Piriyasurawong, 2020). Furthermore, the application of the discovery learning model integrated with the internet of thins in helping students more easily understand the content of the subject matter to be studied. Mustikaningrum &; Mediatati (2021), *the discovery* learning model can improve students' reasoning so that it can improve critical thinking skills in learning. The next step is to test the heterogeneation of the study and the selection of estimation models. The results of the heterogeneity test can be seen in Table 3.

Table 3. Heterogeneity Test Results

	Q	**Df**	**p**

Omnibus Test Of Model Coefficient	14.789	1	0.001
Test of Residual Heterogeneity	5.019	8	0.001

Table 3. Indicates that the value (Q = 5.019 ; P < 0.05) then it can be concluded that the research in this meta-analysis is heterogeneously distributed. Therefore, the meta-analysis model used is a *random effect model.* Next, determine the publication bias used in this study. According to (Chamdani et al., 2022; Musna et al., 2021; Diah et al., 2022)publication bias analysis in analytical research is very important before conducting a research hypothesis test. Analysis of publication bias is carried out with *a funnel plot* which can be seen in figure 1.

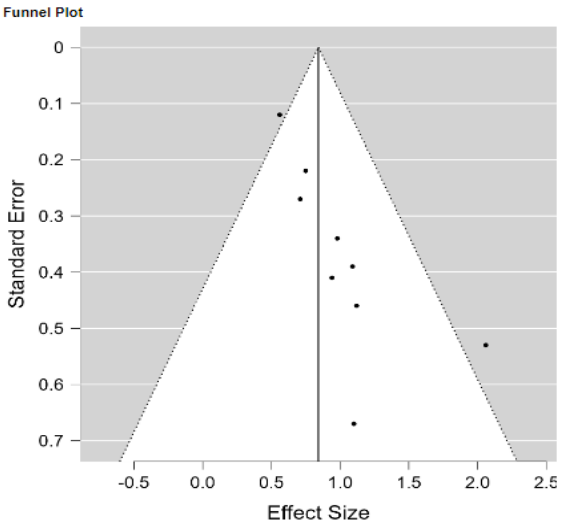

Figure 1. *Funnel Plot*

Figure 1. Showing the spread of effect size is not entirely in a vertical line. Furthermore, it is necessary to perform the Roshintal Fail safe N (FSN) test to determine the resistance of publication bias. The results of the *Roshintal Fail safe* N (FSN) test with the JSAP application are known to have an N value of 254. Furthermore, the calculation result is 254 / (5.9+ 10) > 1 = 4.61 > 1 it can be concluded that there is no publication bias. Next, calculate the p-value to test the research hypothesis. The next step is to calculate the p-value by looking at the comparison of estimation models. The results of the comparison of estimation models can be seen in Table 4.

Table 4. Comparison of Analysis Results based on Random Effect Size Model

	n	Z	p	ICE	ONE	95% CI	Q	p

Model estimation						Lower limit	Upper limit		
Fixed Model	9	8.701	0.00	0.916	0.761	0.79	1.02	48.985	0.001
Random model	9	8.976	0.00	1.065	0.490	0.870	1.24		

Based on Table 3. The Z value was 8,976 with a p value of < 0.00 1and the overall value of the effect size in this study was 1,065 with high criteria. These findings explain that the Internet of Things integrated discovery learning model can improve students' critical thinking skills. Research (Jamaludin et al., 2022; Chusni et al., 2020) That the discovery learning model is effective for encouraging students' critical thinking skills in learning. Diacovery learning model of students in learning to find concepts and theories by themselves (Yaiche, 2021). Furthermore, *the* Internet of Things integrated discovery learning model helps students think logically in solving a problem. The discovery learning model can stimulate problem-solving thinking skills in learning (Permatasari et al., 2018). Therefore, the discovery learning model integrated with the *Internet of Things* is a solution in improving students' higher-order thinking skills.

Conclusion

From this study it can be concluded that the average value of effect size is (ES = 1.06) high criteria. These findings explain that there is a significant influence of the Internet of Things integrated discovery learning model on students' critical thinking skills.The Internet of Things (IoT) integrated discovery learning model can help students be more active and creative in learning. Not only that, the discovery learning model of students can learn on their own in finding theories or concepts by utilizing technology.

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