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Effectiveness of The Internet of Things (IoT)-Based Jigsaw Learning Model on Students' Creative Thinking Skills: A-Meta-Analysis

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Abstract: This study aims to determine the effectiveness of the Internet of Things (IoT)-based Jigsaw learning model on students' creative thinking skills. This research is meta-analysis research. The data sources in this study come from 19 national and international journals published in 2020-2023. Literature search process through Google Scholar, Eric, Springer, ScienceDirect, Sage journal, and ProQuest. Data collection techniques are direct observation and documentation through the journal database. Inclusion criteria are articles or proceedings indexed by SINTA and WOS. Research is in the form of experiments or quasi-experiments. Research is related to the Jigsaw and IoT learning models on students' creative thinking skills and has complete data to be able to calculate the effect size (ES). Data analysis is a quantitative analysis with the help of the JSAP application. The results showed that the average effect size (ES = 0.882) was very high dengan nilai $p < 0.05$. These findings explain that the Internet of Things (IoT)-based jigsaw learning model has a significant influence on students' creative thinking skills. Furthermore, the IoT-based jigsaw model helps teachers be more creative in conveying subject matter to students.

Keywords: Creative thinking; Education; Internet of Things (IoT); Jigsaw models

Introduction

State the Creative thinking is a very important skill for students to have in facing the 21st century (Kartikasari et al., 202; Ramdani, 2016; Ritter et al., 2020). According to Zhu et al. (2013) Creative thinking is an ability that a person has in producing a new idea. Creative thinking trains students in making a decision to solve a problem (Suwendra, 2023; Tabieh & Hamzeh, 2022; Rahman et al., 2023; Suryandari et al., 2021). In addition, students who have creative thinking skills are able to see the world from various perspectives so that they can provide new ideas for solving a real problem (Fitriyah & Ramadani, 2021; Ichsan et al., 2023; Ernawati et al., 2022; Sur & Ateş, 2022). Not only that, creative thinking skills help students more easily understand the subject matter (Ishiguro et al., 2022; Saregar et al., 2021).

Creative thinking skills in students are generally still relatively low (Marwani & Sani, 2020; Utami et al., 2015; Zulyusri et al., 2023; Atmojo & Sajidan, 2020). This can be seen from the 2018 PISA survey on the level of scientific literacy in creative thinking, Indonesian students got 396, ranked 71st out of 78 participating countries (Suryono et al., 2023; Zulkifli et al., 2022; Elfira el al., 2023; Nurtamam et al., 2023). In addition, students' low creative thinking skills are affected by the learning process being too teacher-centered so that students are not actively involved in learning (Supratman et al., 2021; Mursid et al., 2022; Suratno et al., 2019). Furthermore, the selection of the learning model used by the teacher is

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not appropriate so that students find it difficult to understand the subject matter (Supriyadi et al., 2023; Ichsan et al., 2022). In the learning process the teacher does not teach students to think creatively (Rohman et al., 2021), it is necessary to choose the right learning model to encourage students' creative thinking skills.

The Jigsaw learning model is a cooperative learning model that guides students to study in groups (Usman et al., 2022; Safkolam et al., 2023; Affandi et al., 2022). The Jigsaw learning model encourages students to work together and think creatively in learning (Haviz & Lufri, 2019; Cashata et al., 2023; Saputra et al., 2019; Mukrimaa et al., 2016). The jigsaw learning model can train students to be more active and have responsibility in completing a particular task (Berger & Hänze, 2015). Leary & Griggs (2010) the jigsaw cooperative learning model has an influence on improving students' cognitive, affective and psychomotor abilities in learning.

The Internet of Thing (IoT)-based Jigsaw learning model is one of the solutions in improving students' creative thinking skills. Internet of Things (IoT) is a tool that can send data over the internet network (Francisti, 2023; Aydin, 2023; Willner et al., 2020). Internet of Things (IoT)-based learning helps students access information faster (Rodrigues et al., 2023; Mircea et al., 2021). Research result (Aldowah et al., 2017; Abbasy & Quesada, 2020) the application of learning with the help of the Internet of Things (IoT) encourages students to master learning technology and find new ideas in solving a problem. Therefore, the Internet of Things (IoT)-based Jigswa learning model motivates students to learn more creatively.

Previous research by Anderson (2014) the jigsaw learning model encourages the ability to work together in learning and trains students to provide new ideas. Research result (Karacop, 2017) states that the jigsaw learning model can motivate students in learning and understanding concepts. Further research results Dewi et al. (2019) the jigsaw learning model can increase learning motivation so as to encourage student learning outcomes. However, in reality, many studies on jigsaw learning models are still too few studies that describe the size effect of Internet of Things (IoT)-based jigsaw learning models. Based on these problems, this study aims to examine the effectiveness of the Internet of Things-based jigsaw learning model on students' creative thinking skills.

Method

Research Design

This research is a kind of meta-analysis research. Meta-analysis is a type of research that analyzes primary studies that can be analyzed statistically (Yıldırım, 2022; Razak et al., 2021; Putra et al., 2023; Aybirdi, 2023). The meta-analysis study aims to determine the effect of the Internet of Things (IoT)-based jigsaw learning model on students' creative thinking skills.

Data Source

Sources of data in this study came from 13 national and international journals or publications indexed by SINTA and Scopus. Search for data sources through Google scholar, Eric journal, ProQuest, Plos ONE and Wiley. The source tracing method is the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) method which can be seen in Figure 1. The search keywords for data sources are "Jigsaw learning model", "Internet of Things (IoT) and "Think creatively."

Inclusion Criteria

The inclusion criteria in this meta-analysis study are as follows:This type of research is in the form of an experiment or a quasi-experiment; National and international journals or proceedings published 2020-2023; SINTA and Scopus indexed national and international journals or proceedings; The study had an experimental class and a control class; The study should be related to the jigswa learning model, Internet of Things (IoT) and creative thinking skills; The study should report the mean, standard deviation and sample size of the experimental and control classes (or should have the F-value and t-value); The research subjects were elementary, middle and high school students in Indonesia.

Research Variables

The variables in this meta-analysis were: 1) Type of publication (national and international journals and proceedings). 2) Research subjects are elementary, junior high, and high school students. 3) The research variables are Jigsaw learning model, Internet of Things, and creative thinking.

Data Analysis

Data analysis in this study was statistical data analysis with the help of the Comprehnesive Meta-analysis (CMA) version 3.0 application. In addition, SPSS version 21 for normality and heterogeneity tests. Standard deviation and sample size were used to calculate effect size. The overall effect size was calculated with the random effect model. Furthermore, in the meta-analysis, heterogeneity of each study and publication bias were calculated with a sig. 0.05 (Yıldırım, 2022; Ateş, 2021). The criteria for the effect size value can be seen in Table 1.

Table 1. Effect Size Criteria Values (Ateş, 2021; Rahman, 2023; Sofianora et al., 2023; Chamdani et al., 2022)

Effect Size	Criteria
0.0 ≤ Effect Size ≤ 0.10	Ignored
0.10 ≤ Effect Size ≤ 0.30	Low
0.30 ≤ Effect Size ≤ 0.50	Medium
0.50 ≤ Effect Size ≤ 0.80	High
Effect Size ≤ 0.80	Very High

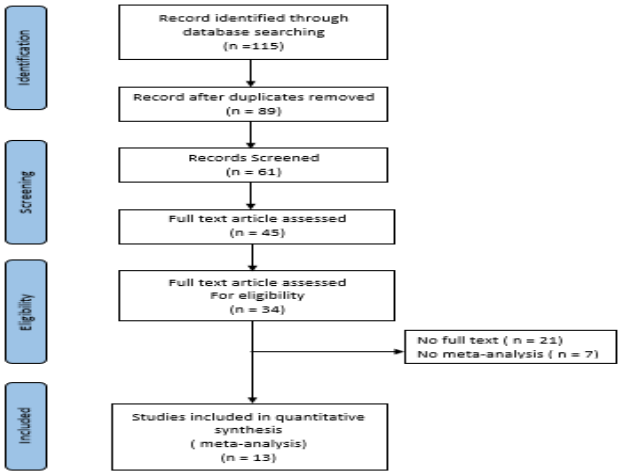

Figure 1. Data selection with the PRISMA method

Result and Discussion

Results

From the analysis of 115 national and international journals and proceedings that have a relationship with the effect of the Internet of Things (IoT)-based Jigsaw learning model on students' critical thinking skills, only 13 journals and proceedings have met the inclusion criteria. Journals and proceedings that meet the criteria are calculated r, t and F values obtained from each study. Furthermore, before the heterogeneity test is carried out, the r, t and F values of each study that does not have an r value are calculated to the r value. The results of the heterogeneity test can be seen in Table 2 and the estimated residual heterogeneity can be seen in Table 2.

Table 2. Heterogeneity Test Results

	Q	df	p
Omnibus Test of Model Coefficients	71.12	1	< 0.000
Test of Residual Heterogeneity	53.77	12	< 0.001

Table 3. Residual Estimate Heterogeneity

	Estimate
t^2	0.061
t	0.280
I^2 (%)	81.90
H^2	14.129

Based on Table 2 the results of the heterogeneity test show that the Q value = 53.77 with a p value <0.000; t2 or t> 0; I2 (%) is close to 100%. The results explain that the effect size in this study is heterogeneously distributed. Furthermore, analyzing the estimation of the average effect size and publication bias calculated by the random effect model. The results of the average effect size can be seen in Table 4.

Table 4. Summary Effect or Mean Effect Size

	Estimate	Standard Error	ES	z	p	95% CI	
						Lower	Upper
Intercept	0.617	0.089	0.882	7.193	0.000	0.395	0.412

Based on Table 4, analysis with random effect model shows a significant effect of Jigsaw learning model and students' creative thinking skills. In addition, the p value shows <0.000, meaning that H0 is rejected and the average effect size (ES = 0.882) is very high. These results explain the positive effect of the Internet of Thigns (IoT)-based Jigsaw learning model on students' creative thinking skills. Furthermore, the publication bias analysis using forest plot of 13 studies can be seen in Figure 2.

Based on Figure 2, the results of the forest plot analysis of the study effect size are -0.03 to 2.40, respectively. The next step is to look at publication bias with Funnel plot. Funnel plot serves to illustrate research publication bias either symmetrical or asymmetrical. The results of the funnel plot analysis of 13 studies can be seen in Figure 3.

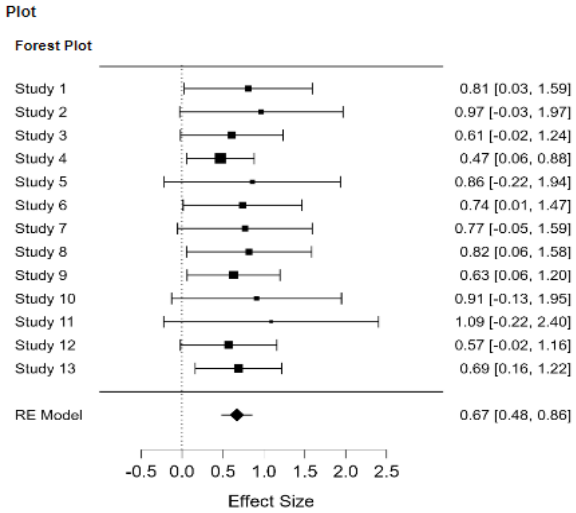

Figure 2. Meta-analysis forest plot

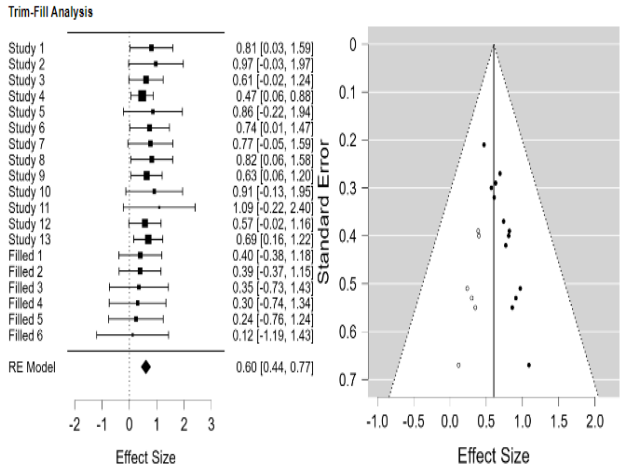

Figure 3. Funnel plot after trim fill diagnosis

Figure 3 shows that the results of the funnel plot analysis do not have a clear indication of symmetrical or asymmetrical publicity bias, so it is necessary to do the Egger test. The Egger test results can be seen in Table 5.

Table 5. Egger Test Results with Regression Test

	z	p
sei	0.612	0.450

Note sei: predictor of standard error

Based on Table 5, shows that the z value = 0.612 or p> 0.05. This explains that the funnel plot is symmetrical. Therefore, there is no problematic publication bias in this meta-analysis.

Discussion

The application of the Internet of Things (IoT)-based jigsaw learning model has a significant effect on students' creative thinking skills. This result can be seen from p < 0.05 and effect size (ES = 0.882) with very high criteria. The results of this study are in line with (Karacop, 2017) Internet of Things (IoT)-based jigsaw learning model helps students improve their science process thinking skills and creativity in learning. Jigsaw learning model trains students to be more active and cooperative in conducting learning activities in the classroom (Wiyono et al., 2021; Suzanti et al., 2023; Kusuma et al., 2022). In addition, the results of research by Silva et al. (2023) stated that the Internet of Things (IoT)-based jigsaw learning model effectively encouraged students' creative thinking skills and learning outcomes.

Akkuş et al. (2022) Jigsw model based on the Internet of Things (IoT) helps students more easily access information via the internet. Internet of Things (IoT) helps students more easily access big data related to learning so as to foster student creativity (Kortuem et al.,, 2013; Brous et al., 2020; Banica et al., 2022; Rahman et al., 2023). Furthermore, the Internet of Things (IoT)-based jigsaw learning model encourages students to be more creative in finding new ideas in solving a problem (Ndia et al., 2021; Zeadally & Tsikerdekis, 2019). Not only that, the jigsaw cooperative learning model has an impact on students' social skills and critical thinking in learning as well as student creativity (Setiawan & Pebriana, 2019; Marwani & Sani, 2020).

Furthermore, each of the research studies analyzed had symmetrical publication bias. The results can be seen in Table 5, z value = 0.612 or p < 0.05. These results explain that the analyzed studies on the Internet of Things-based jigsaw learning model are prone to publication bias. Publication bias describes the vulnerability of each publication (Polat, 2022; Akanbi et al., 2021; Göktaş, 2023). So, the research of Internet of Things (IoT)-based jigsaw learning model can positively affect students' creative thinking skills. So, learning based on the Internet of Things (IoT) helps students learn independently and creatively so as to provide new ideas in learning (Sopapradit & Piriyasurawong, 2020); Rodrigues et al., 2023). So, the IoT-based Jigsaw model is one of the effective solutions in encouraging students' thinking skills (Kamaruddin et al., 2019). The jigsaw model is very effective in developing students' creative thinking and social skills in learning.

Conclusion

From this study it can be concluded that the average effect size (ES = 0.882) was very high with a p value <0.05. These findings explain that the Internet of Things (IoT)-based jigsaw learning model has a significant influence on students' creative thinking skills. Furthermore, the IoT-based jigsaw model helps teachers be more creative in conveying subject matter to students. The Internet of Things (IoT)-based jigsaw model is a solution for teachers to encourage students' creative thinking skills at school.

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Author Contribution

The authors in the study have their respective roles and contributions in completing this research. The first author, collects national and international journal articles with the keywords creative thinking skills. The second and third authors play a role in selecting data in the form of models, types of research, research topics and the association of articles with creative thinking. The fourth and fifth authors, played a role in conducting data analysis with the help of the Comprehensive Meta-analysis (CMA) application.

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Conflicts of Interest
The authors declare no conflict of interest.

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