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The Effectiveness of the Internet of Things in Increasing Students Creativity

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Abstrak

Penelitian ini bertujuan untuk mengetahui efektivitas Internet of Things untuk meningkatkan kreativitas mahasiswa. Jenis penelitian ini adalah meta-analisis. Data penelitian berasal penelusuran database google scholar, ScienceDirect, Researchgate dan Springer. Kriteria inklusi dalam penelitian adalah penelitian dipublikasikan dalam jurnal atau prosiding internasional terindeks Scopus, Wos dan Sinta, Penelitian terkait Internet of Things untuk meningkatkan kreativitas siswa, penelitian harus terbitan 2020-2024, dan penelitian memiliki data yang lengkap untuk menghitung nilai effect size. Analisis statistik dalam penelitian dengan aplikasi JSAP .0.8.5. Hasil penelitian menyimpulkan bahwa implementasi Internet of Things (IoT) berpengaruh signifikan terhadapat kreativitas siswa dengan nilai summary effect size (rRE = 1.117) kategori effect size yang sangat tinggi. Temuan ini menjelaskan Internet of Things efektif membantu siswa dalam meningkatka kreativitas belajarnya di sekolah.

Kata Kunci: *Internet of Things, Effect Size, Kreativitas, Meta-analysis*

The Effectiveness of the Internet of Things in Increasing Students Creativity

Abstract

This study aims to determine the effectiveness of the Internet of Things to increase student creativity. This type of research is a meta-analysis. The research data came from searching the databases of Google Scholar, ScienceDirect, Researchgate and Springer. The inclusion criteria in the research are research published in international journals or proceedings indexed by Scopus, Wos and Sinta, Research related to the Internet of Things to increase student creativity, research must be published 2020-2024, and research has complete data to calculate the value of effect size. Statistical analysis in research with JSAP application .0.8.5. The results of the study concluded that the implementation of the Internet of Things (IoT) had a significant effect on student creativity with a very high summary effect size (rRE = 1.117) in the effect size category. These findings explain that the Internet of Things is effective in helping students increase their learning creativity in schools.

Keywords: *Internet of Things, Effect Size, Creativity, Meta-analysis*

Introduction

Student creativity is one of the important things in supporting the learning process in higher education (Anh et al., 2022; Priyanto & Dharin, 2021). Creativity allows students to think outside the box and solve problems in new ways. Students who have creativity can be realized in various forms such as doing assignments in unique ways, making art, or engaging in extracurricular activities that require imagination and improvisation (Hou et al., 2022). Student creativity is not only important for their personal development, but also benefits society (Oktarina et al., 2021; Zulkifli et al., 2022; Razak et al., 2021). (Revilla et al., 2021) stated that creative students have the potential to make a positive contribution to society through innovation in various fields such as technology, art, science, and humanities. Therefore, creativity needs to be honed and developed from an early age, including in college, so that students are ready to become agents of change in the future (Wang &; Chang, 2022; Rahman et al., 2023; Ichsan et al., 2023; Subali &; Susilo, 2022). One way to develop student creativity is to encourage students to innovate in learning (Prahani et al., 2021; Maulidia &; Abidin, 2020).

But in fact, student creativity in Indonesia is still relatively low (Sari et al., 2018; Suryono et al., 2023; Rahman et al., 2023). According to a survey conducted by the Center for Student Assessment and Learning (PAPM) of the University of Indonesia in 2021, only around 15% of students have high creativity. The rest, as many as 40% of students are at the level of medium creativity and the remaining 45% have low creativity. The low creativity of students is caused by several factors. First, the college curriculum is still theory-oriented and lacks room for the development of creativity (Hanif et al., 2019). Second, a campus environment that does not support the expression of students' ideas and ideas. Third, an academic culture that tends to value obedience and is less tolerant of failure (Lolang et al., 2023), even though the development of creativity requires space to experiment and learn from mistakes (Maulidia &; Abidin, 2020; Pramesworo et al., 2023). Furthermore, in learning activities educators do not involve students to learn so that students lack creativity in learning (Santosa et al., 2021; Ichsan et al., 2022; (Zulyusri et al., 2023; Luciana et al. 2023). Therefore, there is a need for technology-based learning that can encourage student creativity.

Internet of Things (IoT) is a concept where physical objects are embedded with sensors, software, and other technologies so that these objects can connect, communicate with each other and exchange data through the internet network IoT refers to a network of devices that are connected to the internet and are able to exchange data with each other without the need for human interaction (Abdullah et al., 2024; Frydenberg, 2023; Ghudkam et al., 2023). The application of IoT in learning provides many benefits for educators and learners (Francisti, 2023). According to Almadani (2018), IoT helps create a more interesting and interactive learning environment through the integration of various sensors, cameras, and other smart devices. The utilization of IoT in the classroom also enables real-time data collection and analysis. This helps educators understand learners' learning needs more precisely and provides timely feedback (Rouse, 2016). Thus, the proper application of IoT technology can improve the quality of learning in this digital era (Ozgul &; Ucak, 2023; Hou et al., 2022). The government and educational institutions need to continue to develop the use of IoT to create a smarter and more effective learning system.

Previous research has proven that the use of the Internet of Things (IoT) in learning has a positive influence on student learning outcomes and experiences (Hadiati &; Saputri, 2022). According to research conducted by Siregar et al. (2018), the implementation of IoT in physics learning shows an average increase in student learning outcomes by 16.7% and competency achievements of 12.6%. In addition, Mustakim's research (2020) also found that IoT is able to increase student motivation and active participation in mathematics learning. The use of IoT technology has proven effective in enriching the student learning experience and improving student academic performance (Ariswan et al., 2023). Many studies on the Internet of Things in learning have not been meta-analyzed to determine the overall impact of research on the Internet of Things on student creativity. Therefore, this study aims to determine the effectiveness of the Internet of Things to increase student creativity.

Methods

This research is a type of meta-analysis research. Meta-analysis is a type of research that collects and analyzes primary studies that can be analyzed quantitatively (Utomo et al., 2023; Supriyadi et al., 2023; Tamur et al., 2021; Diah et al., 2022; Rahman et al., 2023). This meta-analysis aims to determine the influence of the Internet of Things on student creativity.

Data Collection

Data collection in this meta-analysis searched the databases of Google Scholar, ScienceDirect, Researchgate and Springer. Data search keywords are Internet of Things, Student Creativity and the Influence of Internet of Things on Student Creativity. From the data search, 224 relevant articles were obtained. Furthermore, the articles were selected using the PRISMA method which can be seen in (Figure 1), then 14 articles that meet the inclusion criteria can be seen in Table 2.

Eligibility Criteria

To obtain valid data in the meta-analysis, it is necessary to have eligibility criteria. The eligibility criteria in this study are research published in international journals or proceedings indexed by Scopus, Wos and Sinta, Research related to the Internet of Things to increase student creativity, research must be published 2020-2024, and research has complete data to calculate the value of effect size.

Data Analysis

Data analysis in the meta-analysis calculated the effect size value of the primary study (Glass, 1974). According to Borenstein et al., (2009) The stages of the data analysis procedure for meta-analysis research consist of calculating the effect size value of the study, conducting heterogeneity tests and determining the estimation model, checking publication bias, and calculating the p-value to test the effect size. Statistical analysis with the help of JASP 0.8.5 application. Furthermore, the effect size criteria are guided by the effect size criteria Cohen et al., (2007) which can be seen in Table 1.

Table 1. Effect Size Value Criteria

Effect Size	Category
0.00≤ ES ≤0.20	Low
0.20≤ ES ≤0.80	Medium
ES ≥ 0.80	High

Result and Discussion

Hasil From searching the Google Scholar, ScienceDirect, Researchgate and Springer databases related to the influence of the Internet of Things on student creativity, 14 journals were obtained that met the inclusion criteria. Articles that meet

the inclusion criteria are calculated for effect size values which can be seen in Table 2.

Table 2. Effect Size and Standard Error values

Study Code	Year	Effect Size	Standard Error	Index
Study 1	2020	1.44	0.34	Scopus Q4
Study 2	2020	0.95	0.39	Scopus Q2
Study 3	2023	2.10	0.52	Sinta 2
Study 4	2020	1.19	0.49	Sinta 2
Study 5	2023	0.76	0.22	Sinta 2
Study 6	2023	0.57	0.18	Scopus Q1
Study 7	2023	0.82	0.33	Scopus Q3
Study 8	2021	1.29	0.47	Sinta 3
Study 9	2022	2.40	0.72	Sinta 3
Study 10	2022	2.07	0.30	Scopus Q1
Study 11	2023	1.37	0.32	Scopus Q2
Study 12	2021	0.82	0.28	Scopus q4
Study 13	2020	0.66	0.15	Wos
Study 14	2023	0.83	0.41	Sinta 2

Table 2, the results of the analysis of 14 journal effect size values ranged from 0.66 to 2.40 and standard error ranged from 0.22 to 0.52. According to the effect size criterion Cohen et al., (2007) Of the 14 journals analyzed, three articles with medium effect size values (21.42%) and 11 articles with high effect size criteria (78.58%). This finding explains the influence of the Internet of Things on student creativity. Furthermore, testing heterigenicity and determining estimation models with random and fixed effect models. The heterogeneity test results of the 14 articles can be seen in Table 3.

Result 3. Heterogeneity Test Results

	Q	Df	p
Omnibus Test of Model Coefficients	61.316	1	< 0.001
Test of Residual Heterogeneity	36.827	13	< 0.001

Note. P value are approximate
Note.The Model was estimated Using Restricted ML Methods.

Based on Table 3, the results of the heterogeneity test obtained a value of Q = 61,316 greater than the value of 36,827, then the 14 articles analyzed were heterogeneously distributed. Next, check publication bias with funnel plot analysis and Egger's test (Tamur &; Wijaya, 2021; Chamdani et al., 2022; Hariyadi et al., 2023). The results of the publication bias test with funnel plots can be seen in Figure 1.

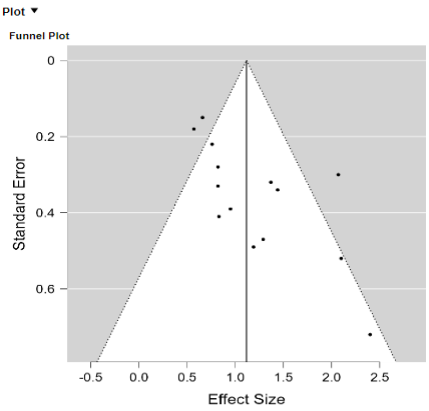

Figure 1. Funnel Plot Standard Error

Based on figure 1, the analysis of publication bias with funnel plots has not yet been said to be the shape of the curve on whether it is symmetrical or asymmetric. Therefore, it is necessary to conduct further tests of Egger's. Egger's test results can be seen in Table 4.

Table 4. Egger's Test Results

	z	p
Sei	3.020	0.003

Table 4, showing the results of Egger's test obtained value Z = 3.020; p< 0.003, then checking publication bias with funnel plots is in a symmetrical curve. The results showed that the analysis of 14 articles did not have publication bias, so no articles were deleted or added. The last step, calculate the p-value with the summary effect size which can be seen in Table 5.

Table 5. Summary Effect Size/Mean Effect Size

	Estimates	Standard Error	z	p
Intercept	1.117	0.143	7.830	< 0.001

Table 4, showing the results of summary effect size obtained value z = 7.830; p < 0.001 and standard error of 0.143, the application of the Internet of Things has a high positive influence on student creativity in the learning process (rRE = 1.117). This finding implies that the Internet of Things is very effective in encouraging student creativity on campus.

The results of this study are in line with Abbasy &; Quesada (2020) The application of the Internet of Things has a positive influence on student creativity. This finding is also supported by the results of the study Dewanto et al., (2023) The Internet of Things can help students learn more creatively, so they have innovation in finding new ideas in learning. Research conducted by Lee et al. (2018) tested the application of the Internet of Things (IoT) in interior design lectures. Students are asked to design smart classroom prototypes by utilizing various IoT sensors. In addition, the Internet of things fosters student creativity in designing designs that are interactive and responsive to user needs (Razzaque, 2019).

Furthermore, another study by Lim et al. (2019) also produced similar findings. In their research, engineering students were asked to make prototypes of medical devices using IoT modules. Students consider the learning process to be able to train their imagination and creative thinking in combining technological components. According to a longitudinal study conducted by Rahman (2021), the application of IoT in product design lectures is significantly able to increase the originality of student design ideas and variations from year to year. This indicates that consistent use of IoT has a positive impact on student creativity (Ardi et al., 2023).

The use of the Internet of Things and other latest technology has high enough effectiveness to train and hone student creativity. Internet of Things-based learning is effectively implemented in higher education to produce graduates who are innovative and ready to work in the digital era. Research from Wu et al., (2016)concluded that the main challenge of implementing IoT in education is to increase the readiness of lecturers in designing creative and effective learning with IoT. Lecturer training is absolutely necessary. (Burd et al., 2017) The Internet of things is generally effective in training student creativity. However, the readiness of lecturers and mature learning design also determine their success Nazir et al., (2019) Training and mentoring need to be provided to lecturers so that maximum IoT implementation increases student creativity.

Conclusion

From this meta-analysis research, it can be concluded that the implementation of the Internet of Things has a significant effect on student creativity with a very high summary effect size (rRE = 1.117) effect size category. These findings explain that the Internet of Things is effective in helping students increase their learning creativity in

schools. The Internet of Things helps students more easily open big data that can train creativity in learning activities.

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