The Effect of the Internet of Things Integrated Discovery Learning Model on Students Critical Thinking Skills: Meta-analysis

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Abstract

This study aims to determine the effect of the internet of things integrated discovery learning model on students' critical thinking skills. This type of research is meta-analysis research. This research data comes from 12 national and international journals published in 2020-2024. Data tracing through Google Scholar, Sage Journal, Researchgate and ScienceDirect. The inclusion criteria in this meta-analysis are research derived from national and international journals indexed by SINTA and Scopus, research must be experimental methods and quasi-experiments, research related to the Internet of Things (IoT) integrated discovery learning model on students' critical thinking skills and research reports complete data to calculate effect size values. Data analysis using Microsoft Excel. The results concluded that there is an influence of the IoT integrated discovery learning model on critical thinking skills with a high mean effect size (ES = 0.915) effect category.

Keywords: Model Discovery Learning; Internet of Things, Critical thinking, Meta-analysis

Introduction

Critical thinking skills are essential abilities that students are highly needed in everyday life and in various professional aspects (Elfira et al.). It involves the ability to analyze
information, structure strong arguments, and make wise decisions based on existing evidence (Suharyat et al., 2022; Rahman et al., 2020). These skills not only help students in solving problems, but also in understanding the world better (Nurtamam et al., 2023). One important aspect of critical thinking skills is the ability to identify relevant information from irrelevant ones. In an era where we are inundated with information from multiple sources, this ability has become invaluable (Illene et al., 2023). These skills help us filter out inaccurate or biased information, so we can make more informed decisions based on valid facts.

Furthermore, critical thinking skills also help students in communicating more effectively (Deborah & Pramono, 2022). With the ability we can structure strong and convincing arguments, and understand other people's arguments better. This opens the door to productive discussions and better collaboration in a variety of contexts, both at work and in social life (Kiriktaş & Şahin, 2021). Critical thinking skills also allow students to develop strong arguments. They can structure their ideas well, use consistent logic, and support their opinions with convincing evidence. This helps students speak and write more persuasively, as well as making them better prepared to participate in intellectual discussions.

But in reality, students' critical thinking skills in learning are still relatively low (Amin et al., 2020; Fitriani et al., 2020). In the learning process, teachers involve students less so as to reduce student interest in learning (Santosa et al., 2021; Razak et al., 2021; Saputra et al., 2019). Critical thinking skills require high effort and dedication. Some students may not feel motivated to develop these skills because they see them as burdensome or irrelevant tasks in their daily lives (Hacioglu, 2021). Lack of motivation of students can result in them not making maximum efforts in improving their critical thinking skills, which can hinder their development in this regard. Furthermore, lack of confidence in developing critical thinking skills (Wenno et al., 2021; Akhmad & Indiatmoko, 2020). They can be afraid to voice their opinions or doubt their ability to critically analyze information. This can be due to fear of criticism or lack of support from their educational environment. This lack of self-confidence can hinder their ability to thrive in critical thinking (Aswan et al., 2018).

The Discovery Learning model is an approach to learning in which students are given the opportunity to explore and discover concepts or knowledge independently (Svinicki, 2024). In this model, the teacher acts as a facilitator or guide of learning rather than imparting knowledge directly to students. Students are given situations or problems that require solving, and they are expected to identify solutions, gather information, and formulate their own understanding (Putri et al., 2020). Discovery Learning emphasizes students' active role in the learning process, allowing them to understand concepts more deeply and develop critical and creative thinking skills (Suwasono & Ali, 2019).

One of the main advantages of the Discovery Learning model is that it encourages students to become independent learners and think critically (Herdiana & Sispiyati, 2017). By giving them the opportunity to explore, test hypotheses, and seek answers on their own, students not only understand concepts more deeply but also develop strong problem-solving skills (From & Ahmad, 2020; Affandi et al., 2022). In addition, this model can increase students' learning motivation, because they feel more involved and have a sense of ownership in their learning process. Although Discovery Learning can be very effective in developing deeper understanding, teachers should ensure that adequate guidance and support is provided to students to ensure accurate understanding and development of student skills (Sinambela et al., 2018).
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Previous research on discovery learning models has a significant influence on students' critical thinking skills (Martaida et al., 2017; Mardi et al., 2021; Mustikaningrum & Mediatati, 2021). But the gap, many studies on discovery learning models have not found meta-analysis of Internet of Things-based discovery learning models on students' critical thinking skills. Therefore, this study aims to determine the effect of the internet of things integrated discovery learning model on students' critical thinking skills.

Research Methods

This study is a type of meta-analysis research. Meta-analysis is research that analyzes and collects secondary data from previous research quantitatively (Diah et al. 2022; Oktarina et al., 2021; Suryono et al., 2023; Ichsan et al., 2023; Dadang et al., 2022). This meta-analysis aims to determine the effect of the internet of things integrated discovery learning model on students' critical thinking skills. Data tracing through google scholar, Sage journal, Researchgate and ScienceDirect. The inclusion criteria in this meta-analysis are research derived from national and international journals indexed by SINTA and Scopus, research must be experimental methods and quasi-experiments, research related to the Internet of Things (IoT) integrated discovery learning model on students' critical thinking skills and research reports complete data to calculate effect size values. Data analysis using Microsoft Excel. Furthermore, the effect size criteria are guided by the effect size (Cohen et al., 2007) can be seen in Table 1.

**Table 1. Effect Size Criteria**

<table>
<thead>
<tr>
<th>Effect Size</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00 ≤ ES ≤ 0.20</td>
<td>Low</td>
</tr>
<tr>
<td>0.20 ≤ ES ≤ 0.80</td>
<td>Medium</td>
</tr>
<tr>
<td>ES ≥ 0.80</td>
<td>High</td>
</tr>
</tbody>
</table>

Results and Discussion

Based on a search of the database of google scholar, Sage journal, Researchgate and ScienceDirect related to the Internet of Things integrated discovery model of critical thinking skills obtained 441 articles. Furthermore, the data was selected according to inclusion criteria obtained by 12 relevant articles to be included in the meta-analysis data. Data that has met the inclusion criteria, calculate the value of effect size and standard error can be seen 2.

**Table 2. Effect Size and Standard Error**

<table>
<thead>
<tr>
<th>Study Code</th>
<th>Year</th>
<th>Effect Size</th>
<th>Standard Error</th>
<th>Criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study 1</td>
<td>2022</td>
<td>0.78</td>
<td>0.32</td>
<td>Medium</td>
</tr>
<tr>
<td>Study 2</td>
<td>2023</td>
<td>0.92</td>
<td>0.26</td>
<td>High</td>
</tr>
<tr>
<td>Study 3</td>
<td>2023</td>
<td>1.25</td>
<td>0.42</td>
<td>High</td>
</tr>
<tr>
<td>Study 4</td>
<td>2023</td>
<td>0.69</td>
<td>0.18</td>
<td>Medium</td>
</tr>
<tr>
<td>Study 5</td>
<td>2024</td>
<td>0.77</td>
<td>0.21</td>
<td>Medium</td>
</tr>
<tr>
<td>Study 6</td>
<td>2024</td>
<td>0.91</td>
<td>0.37</td>
<td>High</td>
</tr>
<tr>
<td>Study 7</td>
<td>2021</td>
<td>0.81</td>
<td>0.28</td>
<td>High</td>
</tr>
</tbody>
</table>
Based on Table 2, the effect size values of the 12 journals analyzed ranged from 0.69 to 2.14. According to the guided effect size Cohen et al., (2007) Of the 12 journals analyzed, 3 journals have medium effect size values and 9 journals have high criteria effect size values.

Discovery Learning model to improve students' critical thinking skills. Emphasis is placed on the importance of developing critical thinking skills in an increasingly digitally connected world. In this section, the author can also explain the reasons why IoT was chosen as an integration element in this learning model and the various benefits expected to be obtained through combining the two (Noviyanti &; Ristanto, 2019). The Discovery Learning model integrated with the Internet of Things (IoT) is an innovative learning approach that seeks to utilize advanced technology in developing students' critical thinking skills (Wang et al., 2013). The research has great significance, given the importance of critical thinking skills in the face of an increasingly complex and connected world. By combining the Discovery Learning model that encourages students to actively explore knowledge with IoT technology that enables real-time data collection and interaction, this study tries to understand its impact on the development of students' critical thinking skills (Lee et al., 2024).

The results showed that the use of IoT-integrated Discovery Learning Model was able to significantly improve students' critical thinking skills (Bin et al., 2010). This is supported by data and findings that show an increase in students' ability to identify problems, gather relevant data, develop hypotheses, and make decisions based on the information they find (Saeid et al., 2018). In this context, IoT provides access to different types of data and information that students can use to support their critical thinking processes. In this regard, this study provides concrete evidence of the benefits of integrating modern technology with an active learning approach (Burd et al., 2017).

Furthermore, the development and implementation of Discovery Learning Models integrated with IoT also has challenges and constraints. These include difficulties in designing curricula that are compatible with IoT technology, teacher training to adopt these models effectively, and data privacy and security concerns in IoT use. Therefore, while this research provides valuable insights, further study is still needed to understand how to effectively overcome these barriers in the application of this innovative learning model.

Conclusion

From this study, it can be concluded that there is an influence of the IoT integrated discovery learning model on critical thinking skills with a high mean effect size (ES = 0.915) effect category. The Internet of Things integrated discovery learning model helps students be
more active and creative in learning. Not only that, the model helps students more easily understand the subject matter.

Reference


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