

## **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 goole 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

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

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### **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).

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 goole 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

Effect Size	Category
$0.00 \leq ES \leq 0.20$	Low
$0.20 \leq ES \leq 0.80$	Medium
$ES \geq 0.80$	High

### Results and Discussion

Based on a search of the database of goole 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

Study Code	Year	Effect Size	Standard Error	Criterion
Study 1	2022	0.78	0.32	Medium
Study 2	2023	0.92	0.26	High
Study 3	2023	1.25	0.42	High
Study 4	2023	0.69	0.18	Medium
Study 5	2024	0.77	0.21	Medium
Study 6	2024	0.91	0.37	High
Study 7	2021	0.81	0.28	High

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Study 8	2023	2.14	0.65	High
Study 9	2023	1.07	0.32	High
Study 10	2022	0.83	0.27	High
Study 11	2021	0.93	0.34	High
Study 12	2023	0.81	0.42	High

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

- Affandi, Y., Darmuki, A., & Hariyadi, A. (2022). The Evaluation of JIDI (Jigsaw Discovery) Learning Model in the Course of Qur an Tafsir. *International Journal of Instruction*, 15(1), 799–820. <https://doi.org/10.29333/iji.2022.15146a>
- Akhmad, Y., & Indiatmoko, B. (2020). The Effectiveness of the Integrated Project-Based Learning Model STEM to improve the Critical Thinking Skills of Elementary School Students. *Educational Management*, 9(1), 9–16.
- Amin, S., Utaya, S., Bachri, S., & Susilo, S. (2020). Effect of problem-based learning on critical thinking skills and environmental attitude. *Journal for the Education of Gifted Young Scientists*, 8(2), 743–755.
- Anike Putri\*, Yenita Roza, M. (2020). Development of Learning Tools with the Discovery Learning Model to Improve the Critical Thinking Ability of Mathematics. *Journal of Educational Sciences*, 4(1), 83–92.
- Bin, S., Yuan, L., & Xiaoyi, W. (2010). *Research on Data Mining Models for the Internet of Things*.
- Burd, B., Divitini, M., Armando, F., Perez, F., Siever, B., & Tudor, L. (2017). *Courses, Content, and Tools for Internet of Things in Computer Science Courses, Content, and Tools for Internet of Things in Computer Science Education*. (January). <https://doi.org/10.1145/3174781.3174788>
- Cohen, L., Manion, L., Lecturer, P., Morrison, K., & Lecturer, S. (2007). *Research Methods in Education*. New York,: Routledge is an imprint of the Taylor & Francis Group, an informa business.
- D M Aswan1\*, L Lufri2, R. S. (2018). Influence of Problem Based Learning on Critical Thinking Skills and Competence Class VIII SMPN Influence of Problem Based Learning on Critical Thinking Skills and Competence Class VIII SMPN 1 Gunuang Omeh . *IOP Conf. Series: Materials Science and Engineering*, 335, 1–6. <https://doi.org/10.1088/1757-899X/335/1/012128>
- Dadang, Indonesia, U. P., Suparman, S., Indonesia, U. P., Avip, B., Martadiputra, P., ... Santu, I. (2022). Does mathematics domain cause the heterogeneity of students' mathematical critical thinking skills through problem-based learning ? A meta-analysis. *AIP Conference Proceedings*, (2468), 1–19. <https://doi.org/10.1063/5.0102714>
- Dari, F. W., & Ahmad, S. (2020). Discovery Learning Model as an effort to improve the critical thinking skills of elementary school students. *Tambusai Journal of Education*, 4(2014), 1469–1479.
- Deborah, R., & Pramono, R. (2022). Implementation of STEM Learning Method to Develop Children's Critical Thinking and Problem Solving Skills. *Journal of Obsession : Journal of Early Childhood Education*, 6(3), 1221–1232. <https://doi.org/10.31004/obsesi.v6i3.1722>
- Diah, H. R., Dayurni, P., Evasufi, L., & Fajari, W. (2022). Meta-Analysis Study : The Effect of Android-Based Learning Media on Student Learning Outcomes. *INTERNATIONAL JOURNAL OF ASIAN EDUCATION*, 3(4), 253–263.
- Elfira, I., & Santosa, T. A. (2023). Literature Study : Utilization of the PjBL Model in Science Education to Improve Creativity and Critical Thinking Skills. *Journal of Science*

- Education Research*, 9(1), 133–143. <https://doi.org/10.29303/jppipa.v9i1.2555>
- Fitriani, A. (2020). PBLPOE : A Learning Model to Enhance Students 'Critical Thinking Skills and Scientific Attitudes. *International Journal of Instruction*, 13(2), 89–106.
- H Sinambela, J., Elvis Napitupulu, E., Mulyono, M., & Sinambela, L. (2018). The Effect of Discovery Learning Model on Students Mathematical Understanding Concepts Ability of Junior High School. *American Journal of Educational Research*, 6(12), 1673–1677. <https://doi.org/10.12691/education-6-12-13>
- Herdiana, Y., & Sispiyati, R. (2017). *Effectiveness of discovery learning model on mathematical problem solving*. 050028. <https://doi.org/10.1063/1.4995155>
- Ichsan, Yayat Suharyat, Tomi Apra Santosa, E. (2023). The Effectiveness of STEM-Based Learning in Teaching 21 st Century Skills in Generation Z Student in Science Learning : A. *Journal of Science Education Research*, 9(1), 150–166. <https://doi.org/10.29303/jppipa.v9i1.2517>
- Illene, S., Feranie, S., & Siahaan, P. (2023). Create multiple-choice tests based on experimental activities to assess students' 21st century skills in the heat and heat transfer topic. *Journal of Education and Learning (EduLearn)*, 17(1), 44–57. <https://doi.org/10.11591/edulearn.v17i1.20540>
- Kiriktaş, H., & Şahin, M. (2021). Effects of Poe on Pre-School Students' Critical Thinking and Poe Skills. *International Online Journal of Primary Education (IOJPE)*, 10(2), 492–509. Retrieved from [www.iojpe.org](http://www.iojpe.org):<https://orcid.org/0000-0002-5230-3041>:<https://orcid.org/0000-0003-4247-483X>
- Lee, C., Kim, J., Ko, H., & Yoo, B. (2024). Addressing IoT Storage Constraints : A Hybrid Architecture for Decentralized Data Storage and Centralized Management Internet of Things Addressing IoT storage constraints : A hybrid architecture for decentralized data storage and centralized management. *Internet of Things*, 25(November 2023), 101014. <https://doi.org/10.1016/j.iot.2023.101014>
- Mardi et al. (2021). Development of Students' Critical Thinking Skills Through Guided Discovery Learning (GDL) and Problem-Based Learning Models (PBL) in. *Eurasian Journal of Educational Research*, 95, 210–226. <https://doi.org/10.14689/ejer.2021.95.12>
- Martaida, T., Hill, N., & Ginting, E. M. (2017). The Effect Of Discovery Learning Model On Critical Thinking Ability In Thematic Learning. *International Conference Education, Culture ...*, 7(6), 1–8. <https://doi.org/10.9790/7388-0706010108>
- Mustikaningrum, G., & Mediatati, N. (2021). Application of The Discovery Learning Model Assisted by Google Meet to Improve Students ' Critical Thinking Skills and Science Learning Outcomes. *International Journal of Elementary Education*, 5(1), 30–38.
- Noviyanti, E., & Ristanto, R. H. (2019). Guided Discovery Learning Based on Internet and Self Concept : Enhancing Student's Critical Thinking in Biology. *Indonesian Journal of Biology and Education*, 2(1), 7–14. <https://doi.org/10.31002/ijobe.v2i1.1196>
- Nurtamam, M. E., Santosa, T. A., Aprilisia, S., Rahman, A., & Suharyat, Y. (2023). Meta-analysis : The Effectiveness of Iot-Based Flipped Learning to Improve Students' Problem Solving Abilities. *Edumaspul :Journal of Education*, 7(1), 1491–1501.
- Oktarina, K., Suhaimi, S., Santosa, T. A., & ... (2021). Meta-Analysis: The Effectiveness of Using Blended Learning on Multiple Intelligences and Student Character Education During the Covid-19 Period. ... *Journal of Education...*, 4(3), 184–192. Retrieved from <http://journal.ummat.ac.id/index.php/IJECA/article/view/5505%0Ahttps://journal.ummat.ac.id/index.php/IJECA/article/download/5505/pdf>

- Rahman, A., & Ristiana, E. (2020). The Influence of the PBL Model on Critical Thinking Skills and Understanding of Science Concepts of Grade V Students of SDN 30 Sumpangbita. *Edumaspul: Journal of Education*, 4(1), 29–41.
- Razak, A., Santosa, T. A., Lufri, & Zulyusri. (2021). Meta-Analysis: The Effect of HOTS (Higher Order Thinking Skill) on Science Literacy Ability and Student Lesson Study on Ecological and Environmental Materials during the Covid-19 Pandemic. *Bioedusiana: Journal of Biology Education*, 6(1), 79–87.
- Saeid, M., Rezvan, M., & Barekatin, M. (2018). Machine learning for internet of things data analysis : a survey. *Digital Communications and Networks*, 4(3), 161–175. <https://doi.org/10.1016/j.dcan.2017.10.002>
- Santosa, T. A., Sepriyani, E. M., Lufri, L., & Zulyusri, Z. (2021). Meta-Analysis: The use of Hots-based modules on ecological and environmental materials in high school. *Journal of Eduscience*, 8(1), 53–56. <https://doi.org/10.36987/jes.v8i1.1976>
- Saputra, M. D., Joyoatmojo, S., Wardani, D. K., & Sangka, K. B. (2019). Developing critical-thinking skills through the collaboration of Jigsaw model with problem-based learning model. *International Journal of Instruction*, 12(1), 1077–1094. <https://doi.org/10.29333/iji.2019.12169a>
- Suharyat, Y., Ichsan, Satria, E., Santosa, T. A., & Amalia, K. N. (2022). Meta-analysis of the application of problem-based learning models to improve students' 21st century skills in science learning. *Journal of Education and Counseling*, 4(5), 5081–5088.
- Suryono, W., Haryanto, B. B., Santosa, T. A., Suharyat, Y., & Sappaile, B. I. (2023). The Effect of The Blended Learning Model on Student Critical Thinking Skill : Meta-analysis. *Edumaspul - Journal of Education*, 7(1), 1386–1397.
- Suwasono, P., & Ali, M. (2019). The Influence of Problem Based Learning on Critical Thinking Ability for Students in Optical Instrument Topic. *Indonesian Journal of Physics Education*, 15(January), 39–45. <https://doi.org/10.15294/jpfi.v15i1.19309>
- Svinicki, M. D. (2024). A THEORETICAL FOUNDATION FOR. *ADVANCES IN PHYSIOLOGY EDUCATION*, 20(1), 4–7.
- Wang, W., De, S., Cassar, G., & Moessner, K. (2013). *Knowledge Representation in the Internet of Things : Semantic Modelling and its Applications*. 54(4), 388–400. <https://doi.org/10.7305/automatika.54-4.414>
- Wenno, I. H., Jamaludin, J., & Batlolona\*, J. R. (2021). The Effect of Problem Based Learning Model on Creative and Critical Thinking Skills in Static Fluid Topics. *Indonesian Journal of Science Education*, 9(3), 498–511. <https://doi.org/10.24815/jpsi.v9i3.20829>
- Yasemin Hacıoglu, F. G. (2021). The Effects of STEM Education on the Students ' Critical Thinking Skills and To cite this article : The Effects of STEM Education on the Students ' Critical Thinking Skills and STEM Perceptions. *Journal of Education in Science, Environment and Health*, 7(2), 1–18.