EKJ Edukimia

Edukimia
e-ISSN: 2502-6399
http://edukimia.ppj.unp.ac.id/ojs/index.php/edukimia/

RESEARCH ARTICLE

Dampak Model Discovery Learning terhadap Keterampilan Berpikir Kritis Peserta Didik Indonesia pada Pembelajaran Kimia: Meta-analisis

The Impact of The Discovery Learning Model on Indonesian Students' Critical Thinking Skill in Chemistry Learning: A Meta-analysis

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ABSTRACT
The Assessment results from Programme for International Student Assessment (PISA) in 2022indicate a decline in the literacy proficiency of Indonesian students. This decline is strongly linked to their low critical thinking, which encompasses the ability to analyze, evaluate, think inductively and deductively, solve problems, and draw conclusions. The selection of an appropriate learning model, such as the discovery learning model, can help students improve their critical thinking skills. A total of 500 articles were gathered from Google Scholar between 2018 and 2023 using the Publish or Perish tool. These articles were obtained by searching for the keywords "discovery learning," "kimia," and "model pembelajaran." The researchers ran a screening process on journal papers, adhering to specific inclusion criteria. As a result, four journal articles were selected, and their effect sizes were determined. The data analysis revealed that the discovery learning model has the potential to enhance students' critical thinking abilities in chemistry education, as indicated by an average impact size of 0.78 falling within the medium category.

KEYWORDS
Discovery Learning Model, Critical Thinking skills, Chemistry, Meta-analysis

ABSTRAK
Temuan Programme for International Student Assessment (PISA) tahun 2022 menunjukkan adanya penurunan tingkat literasi pelajar Indonesia, yang erat kaitannya dengan berpikir kritis, meliputi kemampuan menganalisis, mengevaluasi, berpikir induktif dan deduktif, memecahkan masalah, serta menarik kesimpulan. Pemilihan model pembelajaran yang tepat seperti model discovery learning dapat membantu peserta didik dalam meningkatkan keterampilan berpikir kritisnya. Penelitian ini merupakan studi literatur dengan menggunakan pendekatan meta-analisis dan tahapan PRISMA. Berbagai publikasi penelitian yang dirilis di google scholar selama tahun 2018 hingga 2023 dikumpulkan menggunakan aplikasi publish or perish dengan keyword "discovery learning", "kimia", "model pembelajaran", sehingga menghasilkan 500 artikel. Skrining dilakukan pada artikel jurnal mengikuti kriteria inklusi yang ditetapkan oleh peneliti, menghasilkan empat artikel jurnal yang effect sizenya dihitung. Analisis data menunjukkan bahwa model discovery learning dapat meningkatkan keterampilan berpikir kritis peserta didik pada pembelajaran kimia, dengan rata-rata effect size sebesar 0,78 dengan kategori sedang.

KATA KUNCI
Model Pembelajaran Discovery, Keterampilan Berpikir Kritis, Kimia, Meta-analisis

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https://doi.org/10.24036/ekj.v6.i2.a545

1. INTRODUCTION

The Merdeka Curriculum used in schools emphasizes more than only learning outcomes, particularly in the cognitive realm. The learning process is also evaluated to determine the skills and abilities attained by pupils, one of which is critical thinking. One of 21st century skills learners need to develop is critical thinking, which allows them to examine the clarity of information in society[1,2]. Critical thinking enables learners to critically examine the clarity of information in society, thereby helping them avoid receiving false information. These critical thinking abilities are crucial and can be nurtured through the school's learning processes.

Critical thinking skills are a person's ability to think systematically and logically[3]. Critical thinking skills are demonstrated by analysis, evaluation, deduction, induction, problem-solving, considering multiple options, and drawing conclusions[4]. The 2022 Programme for International Student Assessment (PISA) findings revealed that Indonesian pupils' literacy levels have fallen 12 points since the 2018 PISA results. Only 25.46% of Indonesian pupils fulfil PISA sets' basic literacy proficiency levels[5]. Students are sluggish to respond and solve issues, less adept at applying what they know in everyday life, and have difficulty making judgments[6,7]. This could indicate that Indonesian pupils' critical thinking skills remain low when presented with knowledge or challenge.

Chemistry is a science that mostly consists of abstract factual, conceptualization, procedural, and metacognitive knowledge; it cannot be seen with the naked eye and requires particle-level modeling. This makes it difficult for pupils to understand chemical materials. Providing facts and statistics at the article level can help students practice critical thinking. Moreover, selecting an appropriate learning model, such as the discovery learning model[8], can enhance students' critical thinking skills. Through active participation in group discussions, students engage in stages such as stimulation, problem statements, data collection, data processing, verification, and generalization, fostering deeper conceptual understanding and long-term retention[9]. Teachers play a pivotal role in facilitating the above processes by guiding and supporting students' active participation, ensuring effective learning outcomes.

The role of the teacher in learning using the discovery learning model is less dominant in terms of delivering concepts to students, but the teacher is more likely to guide students in small group and classroom discussions. Aside from that, teachers must prepare materials in the form of student worksheets that will help pupils develop critical thinking skills. Based on the explanation above, the research questions for this study are: How does the discovery learning model affect students' critical thinking skills in chemistry learning? What is the average effect size value of the journal articles received, and what category do they belong in.

Many previous researchers have conducted meta-analysis research on the influence of discovery learning models on students' critical thinking abilities. Hanifah et al. (2022) found that the discovery learning approach had a noteworthy effect on mathematics teaching in junior high schools. They found that the straight line equation material had an average effect size of 2.68, which indicates a significant impact[10]. Noviyanto, W. Y., and Wardani, N.S. (2020) did a comparable study focusing on fifth-grade pupils and their understanding of theme science topics. The discovery learning methodology had a significant impact on students' scientific critical thinking abilities, resulting in an average improvement of 14.39%[11]. In addition, Refelita, F., et al. (2023) conducted a literature review on the use of discovery learning models to enhance students' critical thinking skills in chemistry education. The research's goal was to describe the advancements and trends in the implementation of the Discovery Learning model in chemistry education. A discernible pattern emerged during the period from 2018 to 2023, wherein there was a consistent rise in the quantity of publications that prioritized the development of critical thinking abilities. Out of the numerous papers examined, the majority consisted of quantitative research. The research primarily focused on class XI high school students, with acids and bases being the most frequently chosen study materials, and utilized written examinations and quantitative tests for data collection and analysis[12]. Previous studies have predominantly focused on literature reviews or explored other fields such as mathematics or thematic science content for elementary school students. The lack of a specific meta-analysis that examines the impact of the discovery learning model on students' critical thinking skills in chemistry education, particularly in terms of measuring effect size values, presents a significant challenge. Therefore, there is a need for a comprehensive meta-analysis that specifically investigates how the discovery learning model influences students' critical thinking abilities in chemistry, utilizing rigorous effect size measurements to provide deeper insights into its educational effectiveness.

2. METHOD

This study employs a systematic literature review using a meta-analysis approach. Meta-analysis is a conclusion reached after analyzing the data of multiple previous investigations quantitatively using statistics[13]. This study utilises the PRISMA technique, which involves processes of identification, screening, eligibility assessment, and inclusion[14]. At the identification stage, researchers collected national journal articles and national seminar proceedings published from 2018 to 2023. The publish or perish application was used to collect article data in Google Scholar using the keywords "discovery learning", "kimia", and "model pembelajaran", resulting in a total of 500 publications. Following the initial screening stage, a total of 143 articles were obtained. Subsequently, the article data underwent additional filtration based on the article titles. The third stage, eligibility, involved further selection of articles based on the author's inclusion criteria, which are listed below.

1. The article was published.

2. Articles published between 2018 and 2023.
3. Article types include research articles and seminar proceedings.
4. Research subjects include the impact of chemistry education using the discovery learning model on critical thinking abilities.
5. The research piece is a quasi-experimental study.
6. Research articles provide detailed data, including mean and standard deviation.

The literature review was conducted after selecting publications based on the researcher's inclusion criteria, and four (four) research articles were coded. Following coding, the final step is include. Effect size analysis was used to measure the impact of the discovery learning model on students' critical thinking skills in the teaching of chemistry. Figure 1 depicts the PRISMA steps carried out in this research.

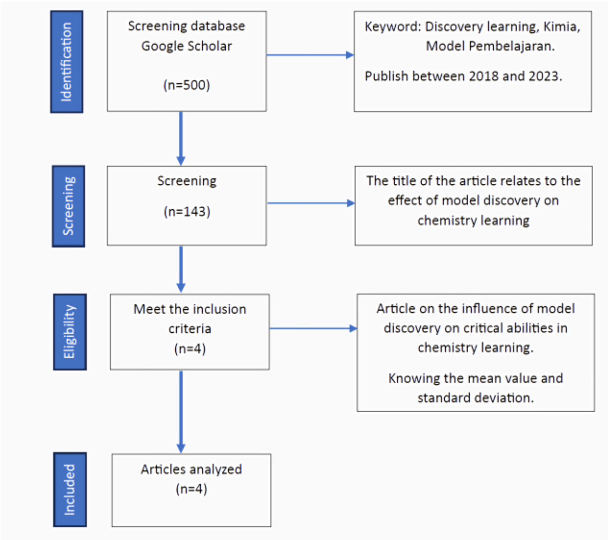

Figure 1. PRISMA Research Stages

Effect size analysis employs two types of formulas tailored to the article's statistical data, as shown in Table 1[15]. Table 2[16] shows the several categories of effect size values.

Tabel 1. Formula for Calculating the Effect Size

No	Statistics	Formula	Formula Code
1	t_{count}	$ES = \frac{\bar{X}_E - \bar{X}_C}{SD_C}$	Fr-1
2	Average for each grup	$ES = t\sqrt{\frac{1}{n_E} + \frac{1}{n_C}}$	Fr-2

Tabel 2. Effect Size Category

Effect Size	Categori
$0 \le ES \le 0,2$	Low
$0,2 \le ES \le 0,8$	Medium
$ES \ge 0,8$	High

3. RESULT AND DISCUSSION

The results of screening journal articles found 4 (four) articles that met the inclusion criteria. There are 496 articles that met the exclusion criteria such as not being a discovery learning model, not measuring students' critical thinking skills, not chemistry learning, not quasi-experimental research, and not presenting mean values and standard deviations. Article data is shown in Table 3, while the results of the effect size calculation are in Table 4.

Tabel 3. Screened article data

Data Code	Researcher	Year	Topic	Conclusion
[17]	Laili, P. I. M., Rehanah, & Multazam	2023	Crude oil	The discovery learning model effect students' critical thinking skills
[18]	Kalsum, U., Sefuddin, & Marhadi, M. A.	2019	Chemical bond	The use of a multi-representation based discovery learning model is more effective in improving critical thinking skills compared to direct learning,
[19]	Mardiani, N.,Perkasa, M., & Mutmainah, P. A	2022	Reaction rate	The discovery learning model effect students' critical thinking skills
[20]	Palupi, M. D., Sudarmin, & Wardani, S.	2018	Hydrolysis	The discovery learning model can improve students' critical thinking skills

Tabel 4. Effect size calculation results

Data Code	*Effect Size*	Categori
[17]	0,637	Medium
[18]	0,738	Medium
[19]	0,711	Medium
[20]	0,827	High
Average	0,728	Medium

According to the effect size calculation, three out of four journal articles have an effect size in the medium range, indicating that the discovery learning model influences students' critical thinking skills when learning chemistry, specifically petroleum materials, chemical bonds, reaction rates, and hydrolysis . The findings of this study were supported by Dari, F.W., and Ahmad, F. (2020), who said that the discovery learning model was effective for students' critical thinking skills in integrated thematic learning for primary school children[21]. Students become more active and critical thinkers in order to discover concepts. After using the discovery learning model, students' critical thinking skills improved by 8% while dealing with the rate of reaction topic[22]. In comparison to the direct instruction model, children who learn using the discovery learning model have a higher average n-gain value[23].

The discovery learning model directs students to build their knowledge through concept discovery without being given the concept from the teacher[24]. Concepts are discovered by students themselves through the steps of the discovery learning model so that students' critical thinking skills are sharpened in the learning process[25]. The discovery learning model encourages students to think critically and analyze so that concepts are discovered through exploration activities of reading sources or data, carried out by students themselves[4].

At the stimulation stage, students are given problems in the form of data, which can be scientific issues developing in society, which will stimulate students to practice critical thinking skills, especially analyzing the information provided. Students formulate several questions based on the stimulation provided, then answer these questions using the knowledge that students have (formulate a hypothesis). When formulating questions and hypotheses, students' ability to create several possibilities and make a decision is trained in this second stage.

In the syntax of data collection and data processing, students analyze the questions given. Students read literature, or carry out and observe experiments, or watch videos to be able to answer these questions. This activity will train problem-solving skills, the ability to think deductively and inductively. Students discover concepts from the material studied at the data collection and processing stage.

After discovering the concept, students communicate and evaluate their answers and those of other groups at the verification stage. Apart from that, students also answer questions on problem identification syntax using the concepts they have discovered. Then students will compare it with the hypothesis that was created previously, so that an evaluation of the hypothesis that was created at the beginning is carried out. Students' ability to formulate conclusions is trained in the final syntax, namely at the generalization stage.

To familiarize students with critical thinking, teachers must design learning in detail, namely by including High Order Thinking (HOT) information and practice questions in teaching modules, reading materials, worksheets and learning media. When students are trained to think critically in the learning process, evaluations can be carried out on target. The role of the teacher as a facilitator who guides students to practice critical thinking skills through the stages of the discovery learning model is also a factor that supports improving students' critical thinking abilities. The teacher also monitors whether participants experience misconceptions during the learning process. If misconceptions occur, the teacher must correct the concept by providing reinforcement.

4. CONCLUSION

The discovery learning model can improve students' critical thinking skills in chemistry learning. This was concluded from the average effect size value of 4 (four) journal articles that had been screened and met the inclusion criteria, namely 0.728 in the medium category. The discovery learning model has a syntax that can train students' critical thinking skills, especially in chemistry learning where the majority of the material is abstract.

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