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Does the Discovery Learning Model Based on Local Wisdom Improve Students' Critical Thinking Skills in Chemistry Learning? Meta-Analysis

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Abstract: The industrial revolution 4.0 has a positive influence on students' critical thinking skills through the discovery learning model. However, whether the discovery learning model based on local wisdom can improve students' critical thinking skills in chemistry learning that does not yet have a uniform conclusion. This study aims to determine whether the discovery learning model based on local wisdom can improve students' critical thinking skills in chemistry learning. This type of research is a meta-analysis. Data was collected through ScienceDirect, Speinger Journal, Researchgate, Mendeley and ERIC. The data entered must meet the eligibility criteria, namely Research must be experimental or quasi-experimental, research comes from SINTA and Scopus indexed journals, Research related to discovery learning models based on local wisdom on students' critical thinking skills in chemistry learning, Research published in 2020-2024, research has complete data to calculate effect size values, and sample size (N) ≥ 25 students. Statistical analysis with the help of JASP. The results of the analysis of 24 studies explained From this meta-analysis research, it can be concluded that there is a significant influence of discovery learing models based on local wisdom on students' critical thinking skills ($z = 11.44$; $p < 0.001$). This effect is included in the very high criterion ($r_{RE} = 1.291$). These findings explain that the discovery learning model based on local wisdom is effective in improving students' critical thinking skills in science learning with a CI of 95% ([1.06; 1.51).

Keywords: Chemistry Learning; Critical Thinking; Discovery Learning; Effect Size; Local Wisdom

Introduction

Critical thinking is a type of ability that students must have in facing the industrial revolution 4.0 (Bangun & Pragholapati, 2021; Elfira & Santosa, 2023; Utomo et al., 2023). Critical thinking skills are one of the important aspects in student development that can affect their ability to understand, analyze, and evaluate information (Sutoyo & Agustini, 2023; Fikriyatii et al., 2022; Azmi et al., 2022; Rahman et al., 2023). Students who have critical thinking skills tend to be better able to make the right decisions, solve complex problems, and develop strong arguments (Liu et al., 2021; Yan, 2021). These skills also help them to become active, creative, and independent learners, as they are able to delve deeper into the subject matter in chemistry learning (Purwanto et al., 2022; Irwanto, 2023).

Furthermore, in chemistry learning the ability of students to think critically is very important. Critical thinking allows them to not just memorize chemical facts (Dijaya et al., 2020), but also to understand the basic principles behind chemical phenomena and apply that knowledge in real-world situations (Suardana et al., 2018; Utami et al., 2017). Students who think critically will be able to ask questions, analyze information, identify patterns, and make in-depth

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conclusions about chemical concepts (Awan et al., 2017; Kriswantoro et al., 2021). Critical thinking skills help students develop a deeper understanding of the subject matter, as well as prepare them for future scientific and technological challenges (Danczak et al., 2017). Therefore, the development of critical thinking skills must be an integral part of chemistry education in order for students to become active and skilled learners in understanding the complex world of chemistry (Acharya, 2017; Danial et al., 2018).

But in fact, students' critical thinking skills in chemistry learning are still relatively low (Utami et al., 2018; Nuswowati & Purwanti, 2018). This is because in teacher learning does not emphasize the learning process to encourage students to think critically (Ariyatun & Octavialis, 2020; Yahdi et al., 2020; Dakabesi et al., 2019). In addition, in chemistry learning teachers use a monotonous learning model so that students are difficult to understand the material (Farah et al., 2020); Suhirman & Khotimah, 2020). Furthermore, research results Trends in International Mathematics and Science Study (TIMSS) in 2015, Indonesian students' critical thinking skills in science only obtained a score of 397 lower than the international average score of 500 (Nurtamam et al., 2023; Suryono et al., 2023; Ichsan et al., 2023). Furthermore, this result is also supported by the results of PISA In 2018 Indonesian students' science literacy obtained a score of 396 ranked 71 out of 78 countries (Rahman et al., 2023; Suharyat et al., 2022; Oktarina et al.,2021). Therefore, there is a need for a learning model that can improve students' critical thinking skills in chemistry learning.

Discovery learning is one of the effective learning models that encourages students' critical thinking skills (Martaida et al., 2017; Chusni et al., 2021; Andayani, 2020). Discovery Learning is one of the learning models that focuses on the active role of students in the learning process (Nursakinah, 2023; Mardi et al., 2021). This model emphasizes the importance of students discovering their own learning concepts and principles through exploration and investigation. In Discovery Learnin, teachers act as facilitators or mentors who provide opportunities for students to explore the subject matter independently or in groups (Shu & Ye, 2023). Students are given questions, problems, or assignments that stimulate their critical thinking, encouraging them to seek answers and understanding on their own through hands-on experience (Ristanto et al., 2022; Maghfiroh et al., 2023). Thus, the Discovery Learning model not only helps students understand concepts more deeply, but also develops critical thinking skills, problem-solving abilities, and motivation intrinsic to learning (Hakim et al., 2018; Nurcahyo et al., 2018).

Furthermore, the discovery model can be combined with local wisdom. Discovery Learning model based on local wisdom students can integrate local culture, traditions, and knowledge in the educational process (Ramdiah et al., 2020). In this model, students are encouraged to explore and understand chemical concepts using cases or examples related to their culture and daily lives (Wilujeng et al., 2019). Through a discovery learning model based on local wisdom, students not only understand chemical concepts theoretically, but also relate them to their cultural context, making them relevant and meaningful (Santosa et al., 2021; Lubis et al., 2022). This not only helps students understand chemistry concepts better, but also fosters a sense of pride in their cultural heritage and promotes a holistic understanding of science within a wider cultural context (Ayun et al., 2020; Fatchurahman et al., 2022).

Previous research on the discovery leaning model provides a positive influence on students' critical thinking skills (Putri et al., 2020; Ekayanti et al., 2022; Dahlan et al., 2023; Solissa et al., 2023; Mustikaningrum et al., 2021). Furthermore, research from outside Indonesia discovery learning models based on local wisdom have a significant influence on students' critical thinking skills (Uge et al., 2019). Research by Warsihna et al. (2020) Learning based on local wisdom can develop students' cognitive skills. Next, research by Yerimadesi et al. (2019) states that the application of the discovery learning model can improve students' critical thinking skills in chemistry learning. However, many studies on discovery learning models have not found meta-analysis of discovery learning models based on local wisdom in chemistry learning. It is necessary to do to find out the effect size of the discovery learning model can be chemistry learning so as to get in-depth conclusions about the model. Therefore, this study aims to find out whether the discovery learning model based on local wisdom can improve students' critical thinking skills in chemistry learning.

Method

Research Design

This research is a type of meta-analysis research. Meta-analysis is a type of research that formulates and analyzes the results of primary research quantitatively (Çevik & Bakioğlu, 2022; Li et al., 2022; Putra et al., 2023; Aybirdi et al., 2023; Razak et al., 2021). This study aims to determine the effectiveness of the discovery learning model based on local wisdom on students' critical thinking skills in chemistry learning. This meta-analysis research procedure is guided by Borenstein et al. (2009) which can be seen in Figure 1.

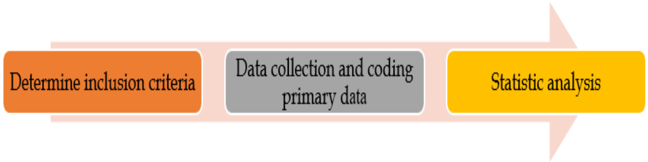

Figure 1. Stages of Meta-analysis

Eligibility Criteria

To obtain reliable and valid data in meta-analysis research, it is necessary to determine inclusion criteria first. Eliligibility criteria are that research must come from national and international journals indexed by Sinta and Scopus, research must be experimental or quasi-experimental, Research related to discovery learning models based on local wisdom on students' critical thinking skills in chemistry learning, Research published in 2020-2024, research has complete data to calculate effect size values, and sample size (N) ≥ 25 students.

Data Collection

Data in this meta-analysis were collected from research related to discovery learning models based on local wisdom on students' critical thinking skills in chemistry learning accessed through databases ScienceDirect, Speinger Journal, Researchgate, Mendeley and ERIC. The keywords of data search are "discovery learning model", the influence of discovery learning based on local wisdom", the influence of discovery learning model based on local wisdom based on critical thinking skills in chemistry learning". From the data search, 23 articles that meet the inclusion criteria selected through the PRISMA method consisting of indentification, Screening, Eligibility and Included can be seen in (Table 2.)

Statistical Analysis

In the meta-analysis of data analysis, calculating the effect size value of the study (Glass, 1976). Data analysis by calculating the value of the effect size of research related to the effectiveness of the discovery leaning model based on local wisdom on students' critical thinking skills in chemistry learning. Statistical analysis in meta-analysis with the help of JASP 0.8.5 application. The statistical analysis procedure is guided by Borenstein et al. (2009) which can be seen in Figure 2.

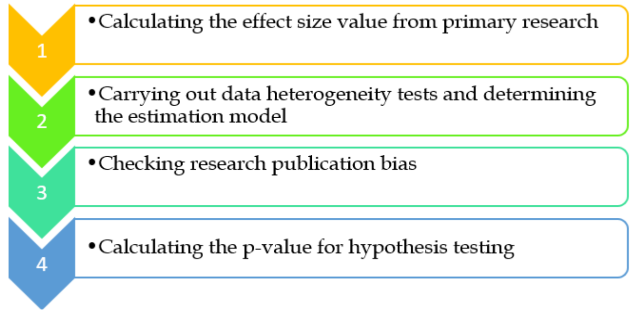

Figure 2. Statistical Analysis Procedures in Meta-analysis Research

Furthermore, the effect size criteria are guided by the effect size criteria (Thaleimer & Cook, 2002) can be seen (Table 1). In addition, the heterogeneity test in this study analyzes the Q value and P value. If the p value > 0.050, the analyzed data is heterogeneously distributed, while if the p value is < 0.050, the analyzed data is not heterogeneous.

Table. 1 Effect Size Value Criteria

Nilai Effect Size	Category
Between -0.15 dan 0.15	Not Effect
Between 0.15 dan 0.40	Low Effect
Between 0.40 dan 0.75	Medium Effect
Between 0.75 dan 1.10	High Effect
Between 1.10 dan 1.45	Very High Effect
1.45 or higher	Amazing Effect

Publication Bias

In meta-analysis research, checking publication bias is very important before testing hypotheses in meta-analyses (Juandi et al., 2022; Chamdani et al., 2022; Tamur et al., 2020). This aims to avoid unpublished research such as theses, theses and dissertations that can affect publication bias (Ridwan et al., 2013). The dissemination of publication bias in this study through the analysis of the funnel plot, Test Egger's and Rosenthal File Safe N.

Result and Discussion

Based on searching articles related to the effectiveness of discovery learning models based on local wisdom on students' critical thinking skills through ScienceDirect, Speinger Journal, Researchgate, Mendeley and ERIC databases, 23 relevant articles were obtained to be included in the meta-analysis data. The relevant data analyzed for effect size and Standard Error (SE) values can be seen in Table 2.

Tabel 2. Effect Size dan Standard Error

Study Code	Year	Country	Journal Index	Effect Size	Standard Error
AP1	2022	Indonesia	Scopus Q4	2.04	0.35
AP2	2020	Indonesia	Feel 2	1.18	0.47
AP3	2023	Pakistanists	Scopus Q3	2.40	0.52
AP4	2023	Indonesia	Feel 2	1.28	0.39
AP5	2021	Indoensia	Feel 3	0.92	0.30
AP6	2023	Turkish	Scopus Q4	1.32	0.35
AP7	2020	India	Scopus Q2	1.48	0.41
AP8	2024	India	Scopus Q2	0.96	0.36
AP9	2023	Bangladesh	Scopus Q4	2.13	0.63
AP10	2022	Indoensia	Feel 4	0.73	0.22
AP11	2022	Indonesia	Feel 4	0.68	0.29
AP12	2022	Indonesia	Feel 2	0.90	0.30
AP13	2022	India	Scopus Q1	1.08	0.24
AP14	2023	India	Scopus Q4	2.19	0.61
AP15	2021	Banglades	Scopus Q4	1.92	0.40
AP16	2023	Iran	Scopus Q2	2.82	0.68
AP17	2023	Indonesia	Scopus Q2	1.33	0.36
AP18	2023	China	Scopus Q1	2.06	0.66
AP19	2021	Indonesia	Scopus Q3	1.14	0.40
AP20	2020	Indonesia	Feel 2	0.62	0.35
AP21	2023	Yunani	Scopus Q2	0.78	0.28
AP22	2023	Mexico	Scopus Q3	1.92	0.37
AP23	2021	Mexico	Scopus Q4	0.95	0.41

Based on Table 2, it shows the value of effect size ranges from 0.73 to 2.82 and standard error ranges from 0.22 to 0.68. According to the effect size criterion Thaleimer & Cook (2002) of the 23 articles entered by meta-analysis data, three articles (n = 3) had a medium effect size criterion, five articles (n = 5) had a high effect size criterion, five articles (n = 5) very high effect size criterion value, and ten articles (n = 10) had an amazing effect value. Next, test the heterogeneity of the data and determine the estimation model used to analyze the average of the 23 effect sizes analyzed. The results of heterogeneity test data through fixed and random effects can be seen in Table 3.

Tabel 3. Fixed dan Random Effect

	Q	Df	P
Omnibus test of Coefficients Model	130.047	1	< 0.001
Test of Residual Heterogeneity	46.755	22	< 0.001

Note. p -values are approximate

Table 3, heterogeneity test results obtained a Q value of 130.047 greater than a value of 46.755 with a confidence level of 95% and a p value of < 0.001, then this can be concluded analysis of 23 heterogeneously distributed effect sizes. Furthermore, to analyze the average value of effect size 23 articles, namely random effect size. Next, checking the publication bias of 23 articles with funnel plot analysis, Egger's test and Rosentahl Fail safe N (Tamur et al., 2020; Puspita & Irfandi, 2022; Chernikova et al., 2020; Li & Ding, 2023). The results of the analysis of 23 articles with funnel flot can be seen in Figure 3.

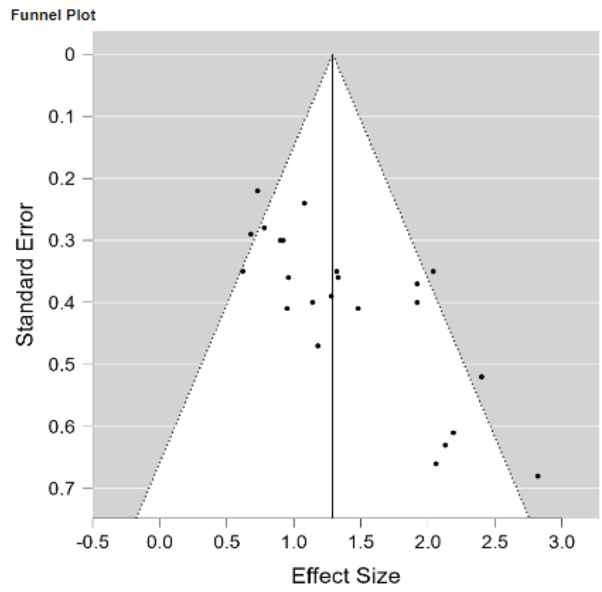

Figure 3. Funnel Plot Random

Based on figure 3, analysis of 23 effect sizes with funnel plots is difficult to conclude whether the funnel plot curve is simitrical or asymmetric, so further tests need to be carried out, namely Egger's test. Egger's test results can be seen in Table 4.

Table 4. Hasil Uji Egger's

	with	p
Six	4.874	< 0.001

Table 4, Egger's test results obtained the value of Z = 4.874 > 1; p < 0.001, then the funnel plot analysis is symmetrical. Furthermore, to increase the validity of the data analyzed in checking publication bias, the Rosenthal Fail Safe N test was carried out. Rosenthal Fail Safe N test results can be seen in Table 5.

Table 5. Hasil Uji Test Rosenthal Fail Safe N

Fila Drawer Analysis	Safe N file	Target Significance	Observed Significance
Rosenthal	2353.000	0.050	< 0.001

Table 5, safe N file value of 2353 with target significance value of 0.050 and Observed significance < 0.00, then k value = 5k + 10 = (5.23) + 10 = 125. Therefore, because nili Fail safe N > 5k + 10 means that in the analysis of 23 articles included in the analysis data there is no publication bias. The last step is to calculate the p-value to test the hypothesis by analyzing the summary effect size which can be seen in Table 6.

Table 6. Summary Effect Size/ Mean Effect Size

Coefficient	Effect Size	Standard Error	z	p	95% CI Lower	95% CI Upper
Intercept	1.291	0.113	11.404	< 0.001	1.069	1.512

Table 6, the results of summary effect size with random effect size model obtained z value = 11.404; p < 0.001 with a 95% lower confidence level of 1.069 and Upper 1.512. Furthermore, the average effect size value of the 23 articles analyzed was 1.291 with very high effect size criteria. The results can be concluded that the discovery learning model based on local wisdom has a significant effect on students' critical thinking skills in chemistry learning compared to conventional learning.

This research is in line with Fadillah et al. (2022) The application of discovery learning models based on local wisdom has a significant influence on students' critical thinking skills. These findings are in line with Papilaya & Tuapattinaya (2022) Learning based on local wisdom is effective in encouraging students' critical thinking skills in chemistry teaching. The discovery learning model based on local wisdom can foster students' science literacy so that it can encourage critical thinking skills in learning (Suastra et al., 2021; Suja et al., 2023). Furthermore, discovery learning models based on local wisdom can increase students' character and interest in understanding their culture (Yusuf, 2023).

Furthermore, the discovery learning model is based on local wisdom in improving higher-order thinking skills in chemistry learning (Setiadi & Elmawati, 2019; Lubis et al., 2022). This learning model combines a constructivistic approach with the use of local wisdom as a contextual foundation (Suardana et al., 2020). Local wisdom-based discovery learning models can activate students more actively in the learning process, giving them the opportunity to explore their own knowledge and develop critical thinking skills. The discovery learning model based on local wisdom is also closely related to the way students can relate chemical concepts to their local environment and culture (Permatasari & Laksono, 2019). This can increase students' interest in chemistry learning because they can see the relevance and applicability of the subject matter in their daily lives (Agusta et al., 2021). In addition, students' discovery learning models based on local wisdom can develop analysis, synthesis, and evaluation skills, which are essential skills in dealing with real-world challenges.

Improving students' critical thinking skills through discovery learning models based on local wisdom can make a significant contribution to the development of more effective learning models in chemistry (Yerimadesi et al., 2022). It can also inspire teachers and educators to better utilize aspects of local wisdom in their teaching to make chemistry learning more interesting, relevant, and rewarding for students. The discovery learning model based on local wisdom in chemistry learning has several very important advantages. First, the model encourages students to be active in the learning process, so that they can develop a deeper understanding of chemical concepts. Through their own exploration and discovery, students can understand how chemical concepts relate to their environment and culture, so that learning materials become more relevant and easy to understand.

This discovery learning model based on local wisdom encourages student involvement in problem solving and decision making that can foster students' critical thinking skills in chemistry learning (Frisilla, 2022). They are invited to identify problems that exist in the context of their daily lives and find solutions based on chemical concepts that have been learned (Utaminingsih, 2021; Nuraisyah et al., 2020). This not only develops students' critical thinking skills, but also prepares them to deal with real situations outside the classroom that require an understanding of chemistry. Thus, discovery learning models based on local wisdom can enrich students' learning experiences in chemistry and provide a strong foundation for a deep understanding of chemistry.

Conclusion

From this meta-analysis research, it can be concluded that there is a significant influence of the discovery learing model based on local wisdom on students' critical thinking skills (z = 11.4-4; p < 0.001). This effect is included in the very high criterion (rRE = 1.291). These findings explain that the discovery learning model based on local wisdom is effective in improving students' critical thinking skills in science learning with a CI of 95% ([1,06; 1,51). The discovery learning model based on local wisdom can foster student interest and student character in implementing culture in chemistry learning. Not only that, this model makes it easier for students to analyze and evaluate lessons so as to encourage students' critical thinking skills.

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Author Contributions

The research consists of two researchers who have contributed, namely Elisabeth Temuji Koten contributed in collecting, selecting, analyzing and interpreting research data, while Eli Rohaeti contributed in proofreading research results.

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Conflicts of Interest
The authors declare no conflict of interest.

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