BIO-INOVED
Jurnal Biologi-Inovasi Pendidikan
Volume 5, Issue 2, June 2023 page. 171-178

P-ISSN : 2684-9062 | E-ISSN : 2714-9803
https://ppjp.ulm.ac.id/journal/index.php/bino
DOI: 10.20527/bino.v5i2.16030

Meta-analysis: The effect of guided inquiry on students' critical thinking skills in biology learning

Dewi Asriani Ridzal *, Mujuna Hatuala, Haswan, Farnia

Study Program of Biology Education, Faculty of Teacher Training and Education, Universitas Muslim Buton, Baubau, Southeast Sulawesi, Indonesia

**Corresponding Author Email:* dewiasrianiridzal86@gmail.com

Article Information

Keyword:
Meta-analysis; Guided inquiry; Critical thinking; Biology learning

Kata Kunci:
Meta-analisis; Inkuiri terbimbing; Keterampilan berpikir kritis; Pembelajaran biologi

History:
Received : 04/04/2023
Accepted : 14/06/2023

Abstract

Critical thinking skills are one of the six skills (6C) that must have by students to face competition in the 21st century. Guided inquiry is one of the learning models that can be used to increase students' critical thinking skills in biology learning. The purpose of the study was to determine the effectiveness of the enforcement of the guided inquiry model, especially on students' critical thinking skills in biology learning based on the effect size value in terms of education level. This research method is a meta-analysis method. The research sample taken from 12 national articles consists of seven journals at the high school level and five journals at the junior high school level. The results showed that the guided inquiry model was effectively used both at the high school and junior high school levels because it was proven to have a forceful impact on students' critical thinking skills in biology learning with an average effect size value of 1.651 (strong effect). Based on the level of education, the enforcement of the guided inquiry model at the high school level has a higher impact on student's critical thinking skills with an effect size value of 1.866 (strong effect) than at the junior high school level with an effect size value of 1.435 (strong effect). This guided inquiry model needs to be applied more broadly so that more students have critical thinking skills and ready to compete in the global world.

Abstrak

Keterampilan berpikir kritis merupakan salah satu dari 6 kecakapan (6C) yang harus dimiliki oleh siswa agar dapat menghadapi persaingan di abad 21. Inkuiri terbimbing menjadi salah satu model pembelajaran yang dapat digunakan untuk meningkatkan keterampilan berpikir kritis siswa pada pembelajaran biologi. Tujuan penelitian adalah untuk mengetahui efektivitas penerapan model inkuiri terbimbing khususnya terhadap keterampilan berpikir kritis siswa pada pembelajaran biologi berdasarkan nilai besarnya efek ditinjau dari jenjang pendidikan. Jenis penelitian ini adalah meta analisis. Sampel penelitian terdiri dari 12 artikel yang terdiri dari 7 jurnal pada jenjang SMA dan 5 jurnal pada jenjang SMP. Hasil penelitian menunjukkan model inkuiri terbimbing efektif digunakan baik pada jenjang SMA maupun SMP karena terbukti dapat memberikan pengaruh yang sangat kuat terhadap keterampilan berpikir kritis siswa pada pembelajaran biologi dengan nilai rerata besaran efek sebesar 1.651 (efek kuat). Berdasarkan jenjang pendidikan, penerapan model inkuiri terbimbing pada tingkat SMA memiliki pengaruh yang lebih besar terhadap keterampilan berpikir kritis siswa dengan nilai besaran efek sebesar 1.866 (efek kuat) dibanding ditingkat SMP dengan nilai besaran efek sebesar 1.435 (efek kuat). Model inkuiri terbimbing ini perlu diterapkan secara lebih luas agar lebih banyak peserta didik yang memiliki keterampilan berpikir kritis dan siap bersaing di dunia global.

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A. Introduction

The guided inquiry has been one of the specified strategic for the 21st century (Owolade et al., 2022). The enforcement of the guided inquiry learning model provides more opportunities for students to find facts, concepts, and principles through their own direct experience (Ika et al., 2017) so that students get the opportunity to practice and develop process skills, thinking skills, and scientific attitudes (Maryam et al., 2020). Guided inquiry is a learning model that can facilitate students to develop concepts through the thinking process (Diani et al., 2017).

Guided inquiry is a learning model that maximally engages all students' potential to search and investigate systematically, critically, logically, and analytically (Suryaningsih et al., 2016) so that students can find their concepts or knowledge with confidence (Masitoh & Ariyanto, 2017). Guided inquiry is an enforcement of constructivist learning based on scientific observation and study. Constructivism is a philosophy that emphasizes that the knowledge students have is the result of the students' construction (Furmanti & Hasan, 2019). The enforcement of guided inquiry models in learning is one of the effective solutions that can be used to overcome students' weak critical thinking skills (Utami, 2022)

Critical thinking skills are one of the six components (6C) of the 21st century that students must have (Fikri et al., 2020) to be ready to compete in the global world (Sarifah & Nurita, 2023). Critical thinking is among the most essential and required skills in 21st-century education because it is believed to have a higher role in helping learners to live and work successfully (Tindowen et al., 2017) and is the key to the future of all societies in the world (Wayudi et al., 2020)

Critical thinking becomes indispensable when humans are up against the swift flow of information due to the explosion of technological and information advances so everyone can select relevant and valid reviews (Cahyono, 2017; Prasetyo, 2018). Critical thinking is a process of intellectual skills that are needed (Sudarisman, 2015) to understand, apply, evaluate, synthesize, and analyze information carefully and objectively (Mashudi, 2021) and be able to help students make strong arguments (Annisa et al., 2021)

The weak learning process is one of the problems faced by education in Indonesia. Students are less trained to understand and build concepts independently, develop thinking skills, and find solutions to solve problems. The learning process in the classroom still tends to memorize various information without being required to understand and apply the information in everyday life (Waleulu et al., 2019; Ridzal et al., 2022). This is supported by the results of the 2018 PISA survey that the ability of Indonesian students in the science category is still relatively low, namely obtaining a score of 396 lower the average OECD score of 489 which puts Indonesia in the sixth position from the bottom (Harahap & Harahap, 2021).

Previous research suggests several problems that cause students' low critical thinking skills, namely the lack of student interest and ability (Rahmadani et al., 2017), the way teachers teach is not following the needs of students and does not vary (Mahmuda et al., 2018; Siregar et al., 2022; Triyono et al., 2022), evaluation questions have not been directed at students' critical thinking skills (Wahyuni et al., 2019), learning is still teacher-centred (Iskandar et al., 2021), the biology learning process students only rely on theory or transfer of knowledge so that it is difficult for students to apply when faced with reality (Ismail et al., 2019).

Some previous research results confirm that the enforcement of guided inquiry models has a significant impact on various student competencies in biology learning especially for student critical thinking (Falahudin et al., 2016; Nonci et al., 2018; Ramadan et al., 2019; Aiman et al., 2020; Roana et al., 2022). This shows that the implementation of the guided inquiry model is very effective in learning biology because it is can be proven to have a significant effect on improving students' critical thinking skills at both junior and senior high school levels. The results of these studies are the basis for researchers to conduct meta-analysis research on the effect of guided inquiry models on student competencies, namely critical thinking skills in biology learning.

Meta-analysis is a technique used to summarize various research results quantitatively and integratively by finding the effect size value. The effect size value describes the effect of the independent variable that is intervened in the experimental group on a dependent variable (Anthony et al., 2015). This study focuses to determine the effectiveness of the enforcement of the guided inquiry model, especially on students' critical thinking skills in biology learning based on the effect size value in terms of education level.

B. Material and Method

The type of research used is meta-analysis. Meta-analysis is research that summarizes, reviews, and analyses data from several previous studies (Anugraheni, 2018). This research was conducted by reviewing 12 articles on the effect of guided

inquiry learning models on critical thinking skills in biology learning from 2016-2022. The distribution of articles that became the research sample can be seen in the Table 1.

Table 1 Distribution of Research Article Samples

Article Code	Research Topic and Author	Grade
GI1	The effect of guided inquiry learning model on critical thinking skills of X MIA class students on environmental pollution material in Surakarta. (Siregar et al., 2022)	Senior High School
GI2	The influence of guided inquiry learning toward critical thinking skills of X MIA students on environtmental pollution material in Surakarta (Masitoh & Ariyanto, 2017)	Senior High School
GI3	The effect of guided inquiry learning model on students' critical thinking skills in biology learning (Ritli & Adlini, 2022)	Senior High School
GI4	The effect of guided inquiry learning models on senior high school students' critical thinking skill (Hadijah et al., 2020)	Senior High School
GI5	The effectiveness of guided inquiry model with starter experiment approach towards critical thinking skill in understanding fungi material: an experimental study on the first students of senior high school (Wardani & Djukri, 2020)	Senior High School
GI6	The effect of guided inquiry learning strategy on critical thinking ability of students of SMAN 1 Na IX-X (Ritonga, 2019)	Senior High School
GI7	The impact of using modules and LKPD in learning circulatory system based on guided inquiry on critical thinking and creative thinking skills students of SMA Negeri 1 Raha (Anny et al., 2021)	Senior High School
GI1A	The effect of guided inquiry learning model on learning activities and critical thinking skills of seventh grade students of SMP Negeri 1 Liliriaja; Study on environmental pollution material (Nonci et al., 2018)	Junior High School
GI2A	The effect of guided inquiry learning model on critical thinking ability, motivation and student activity at SMPN 5 Seluma (Furmanti & Hasan, 2019)	Junior High School
GI3A	Differences between guided inquiry and discovery learning models on scientific attitude, critical thinking and cognitive outcomes of SMP 2 Kepahiang (Ramadan et al., 2019)	Junior High School
GI4A	The effect of guided and project inquiry methods on critical thinking ability of biology students at SMP Swasta HKBP Simantin Pane (H. S. Harahap et al., 2020)	Junior High School
Gi5A	The effect of guided inquiry learning model on students' critical thinking ability in learning environmental management material at SMP Negeri 2 Tanjung Lago, Banyuasin Regency (Falahudin et al., 2016)	Junior High School

The data analysis technique used in this study is to calculate the effect size of each research sample using the Cohen formula (Boisandi & Darmawan, 2017), namely Formula 1.

$$d = \frac{Mposttest - Mpretest}{\sqrt{\frac{SD^2posttest + SD^2pretest}{2}}} \text{.....Formula 1}$$

Description:
M = Average test score
SD = Standard deviation of test scores

The interpretation of the effect size value uses the criteria (Taufik et al., 2022) as Table 2.

Table 2 Criteria for Effect Size Assessment

Criteria	Interpretation
0.0-0.20	Weak Effect
0.21-0.50	Modest Effect
0.51-1.00	Moderate Effect
>1.00	Strong Effect

C. Results and Discussion

The 21st century, known as the century of knowledge, focuses on developing students' skills in solving problems, thinking creatively, communicating well, and collaborating in teams. Science education, especially biology, can be a means to enhance 21st-century skills (Setyasih et al., 2022). Critical thinking is one of the skills that must be mastered by students. Guided inquiry is a learning model that can be used to train and enhance students' critical thinking skills because in this model various activities can encourage students to empower their thinking abilities (Ritonga, 2019).

Biology learning as part of the process- and product-oriented science has an important role in improving the quality of education presented with inquiry methods that can encourage the advancement of critical thinking skills and work on their initiative (Novitasari et al., 2017). The usage of the guided inquiry model will encourage students to think and work on their initiative. These habits can stimulate and improve students'

critical thinking, by searching and finding answers to the problems formulated (Hadijah et al., 2020).

Critical thinking skills must exist in the learning process as a form of horizontal mutual interaction that occurs between students and teachers (Bustami et al., 2019) because critical thinking skills are needed as a form of student mental formation process (Bustami et al., 2018) through the stages of analysis, synthesis, and evaluation of biological concepts (Setyasih et al., 2022).

The results of the calculation of the effect size of each article used as a research sample are then interpreted to determine how much impact the guided inquiry model has on critical thinking skills in biology learning (see Table 3).

Table 3 Effect Size of Guided Inquiry Model on Biology Learning

Article Code	Level	Effect Size	Category of Effect Size	Average of Effect Size	Average of Effect Size
GI1	Senior High School	6.943	Strong	1.866	Strong effect
GI2		0.633	Moderate		
GI3		1.613	Strong		
GI4		0.579	Moderate		
GI5		0.965	Moderate		
GI6		0.667	Moderate		
GI7		1.664	Strong		
GI1A	Junior High School	0.965	Moderate	1.435	Strong effect
GI2A		0.371	Modest		
GI3A		2.945	Strong		
GI4A		1.954	Strong		
GI5A		0.942	Moderate		
Average of total effect size				1.651	Strong effect

Table 3 shows the distribution of the research sample articles divided into two groups based on the level of education, namely seven articles at the high school level and five articles at the junior high school level. Based on the effect size analysis at the high school level sample code GI1 obtained an effect size value of 6.943, GI2 of 0.633, GI3 of 1.613, GI4 of 0.579, GI5 of 0.965, GI6 of 0.667 and GI7 of 1.664. The effect size value is the junior high school sample with the code GI1A of 0.965, GI2A of 0.371, GI3A of 2.945, GI4A of 1.954, and GI5A of 0.942. Effect size that is in the range of values 0.50 - 1.00 indicates that the enforcement of guided inquiry provides a moderate effect on the development of critical thinking skills of biology students. Effect size is > 1.00 showed that the enforcement of guided inquiry provides a big effect on the development of critical thinking skills of biology students.

Articles with code GI1 at the high school level have the largest effect size value of 6.943 and are included in the strong effect category and GI4 has the smallest effect size value of 0.579 and is included in the moderate effect category. Articles with code GI3A at the junior high school level have a higher effect size value of 2.945 and are included in the strong effect category and GI2A has the smallest effect size value of 0.371 and is included in the moderate effect category.

Based on the level of education, the average effect size value at both the senior high school and junior high school levels is greater than 1.00 (strong effect). The average effect size value in high school is 1.866 and in junior high school is 1.435 there is a difference of 0.431. This indicates a strong effect of the enforcement of guided inquiry in developing students' critical thinking skills at both junior and senior high school levels. This is because, the higher the level of education, the better the ability of students to analyze relevant data to be used as a learning resource and of course will hone critical thinking skills (Praminingsih et al., 2022) and students are able to think abstractly and logically (Kurniawati et al., 2019).

The difference in the mean value of the effect size indicates that the guided inquiry model makes a greater contribution to the critical thinking skills of high school biology students compared to junior high school students. Nevertheless, it can be concluded that this guided inquiry model is effectively applied at both junior and senior high school levels because it is proven to be able to have a significant effect on the development of student's critical thinking skills. This result is in line with (Wardani & Djukri, 2020; Ritli & Adlini, 2022; Salama, 2022) which states that the enforcement of the guided inquiry model in biology learning is able to make a significant contribution to students' critical thinking skills at both the junior and senior high school levels because actively involves students in discussions and experiments so that

they can understand the facts and concepts of the material being studied.

The average effect size of the whole article is in the strong impact category with a value of 1.651 and is strong. This is different from the results of research (Rachman & Jauhariyah, 2020) in that the enforcement of the guided inquiry learning model has a moderate impact on improving critical thinking skills in physics learning. The guided inquiry model is very suitable to be applied in learning because it is very fun, can train students to work independently, help the critical thinking process, and help students understand the material and can create an active learning atmosphere (Nurfasiah, 2015).

D. Conclusion

Based on the results of the meta-analysis, it can be concluded that the guided inquiry gave a strong impact on critical thinking skills in student biology learning with an overall average effect value of 1.651. This shows that the performance of the guided inquiry model is proven to be very effective in helping to enhance student critical thinking skills in biology learning. The mean effect size value at the high school level was 1.866 and the junior high school level was 1.435 and both were in the strong effect category. This proves that the guided inquiry model is effectively used not only at the junior high school level but also at the senior high school level.

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