



# Meta-Analysis Effectiveness of Using the Discovery Learning Model on Students' 21st-Century Critical Thinking Skills

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**Abstract:** Critical thinking skills greatly support students to think analytically, thus making themselves intelligent. Two factors influence students' critical thinking skills, including the first from teacher resources. This study aims to determine empirical data related to the effectiveness of using the Discovery Learning Model for students. The method used is meta-analysis, namely a statistical review by analyzing the results of research published internationally related to the use of the Discovery Learning model on critical thinking skills. The analysis sample consists of 4 international journals published in 2017 - 2022 at the high school level, which discuss the writing of experiments on the effectiveness of using the Discovery Learning model on critical thinking skills. The writing instrument is in the form of a coding sheet that summarizes journal data and information. Based on the analysis of the overall influence value, the average value of the effectiveness effect is  $\geq 0.8$ , which means it is in the large effect category. The findings of the analysis also show that the effectiveness of using the Discovery learning model affects increasing critical thinking skills compared to conventional methods. This provides the conclusion that the use of the Discovery Learning model on critical thinking skills is effective in learning.

**Keywords:** Critical thinking skills; Discovery learning

## Introduction

The 21<sup>st</sup> century demands student competency in terms of knowledge, skills, attitudes, and values. (Santosa et al., 2022). The 21<sup>st</sup> century demands skills in all areas including critical thinking, communication, collaboration, and creativity skills (Haryani et al., 2021; Herlinawati et al., 2024). Critical thinking is a critical thinking skill, namely thinking comprehensively, which includes interdisciplinary science. John Dewey, the father of the modern critical thinking tradition (Sellars et al., 2018; Zhang, 2022), argues that critical thinking is essentially an active process of thinking deeply, asking questions, and finding relevant information rather than just receiving information passively. Critical thinking skills greatly support students to think analytically, thus making themselves intelligent (Simonovic et al., 2023; Walter, 2024). Two factors influence students' critical

thinking skills, including the first from teacher resources. Secondly, from the external environment, namely from stakeholders, there is still a lack of learning support that leads to the demands of learning 21<sup>st</sup>-century skills (Karaca-Atik et al., 2023; Hermundsottir & Aspelund, 2021). During the final semester assessment test or PAS, the role of the question maker also affects students' critical thinking skills because they rarely provide analytical essay questions, and even the C4 analysis type of questions do not appear at all so students feel they do not need to learn C4 (analytical) questions (Jiang, 2020).

The reality in the field based on a survey in preliminary research, the profile of critical thinking skills of junior high school students, especially in social studies subjects, is still weak. We can see this in daily practice in social studies learning in junior high schools, namely some information that researchers have

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obtained, including teachers have not used the right learning models and methods, have not used the right learning approach, have not used good assessments, the average social studies score has not reached the minimum completion criteria, which is less than 75 or still below the KKM (Minimum completion criteria) score. Students find it difficult to answer daily tests or formative tests for analytical questions, only memorization questions that they can answer because teachers are not used to teaching analysis to students. Mostly. Likewise, during the summative test, it was seen that for analytical questions, students were not optimal in answering and often did not answer at all. This can weaken students' critical thinking skills because students are not used to practicing working on C4 (analysis) questions.

All of the above causes will affect the weakness of students' critical thinking skills. Students' critical thinking skills that are still weak are very contrary to the demands of the 21<sup>st</sup> century which emphasize critical, analytical, and comprehensive thinking. To be highly competitive, learning is not just about memorization because so, far the mindset of social studies is a lesson that is only memorization (Murphy et al., 2023; Abdulrahman et al., 2020). Lessons that are memorization will only shackle students or limit students' room for movement. It does not give students the freedom to think critically and explore their potential from various scientific perspectives (Kawuryan et al., 2022; Southworth, 2022).

Meanwhile, critical thinking skills have not received special attention, especially for cognitive C4 (analysis). According to John Dewey, "Schools must teach children the right way of thinking" (Sari et al., 2021). Dewey stated that critical thinking is essentially a person's active thinking where someone thinks about things more deeply, asks questions, and finds relevant information rather than just receiving things (information) passively. (Dwivedi et al., 2023). Deep thinking related to the problems and early experiences of students that are associated with various points of view has not been done or is rarely found in practice in learning in schools. In the learning of scientific disciplines that are usually applied so far, both students and teachers are on average passive to think deeply. Students rarely ask teachers and teachers ask students. They only receive information passively. If this condition is allowed, they will not find other information that can increase knowledge. So that the knowledge they have is limited or underdeveloped. Learning models that challenge finding relevant and valid information are rarely done so they do not support students' critical thinking.

Reflection activities between teachers and students are rarely done in learning because when the material

and questions are finished, they generally forget to reflect further on both the advantages and disadvantages of the learning process and the new learning content. (Ketonen & Nieminen, 2023). As a result, students do not build a new generalization. So that there are no new findings and learning is less comprehensive and meaningful (Markula & Aksela, 2022; Haleem et al., 2022). Critical thinking skills can be used as a goal to deal with changes in the field of science and technology that are difficult to control (Nowell et al., 2017). Seeing the situation above, if we just let what happens in the field and do not fix learning properly, students' critical thinking skills will always be weak. If students' critical thinking skills are weak, the impact will be that human resources will be of poor quality, student achievement will be low, and competitiveness will be low.

We observe that the studies that have been carried out above emphasize the Discovery Learning model in learning that emphasizes the work process or projects in learning scientifically from various scientific perspectives thus improving critical thinking skills. So that the research is relevant to what the researcher will do. Seeing the four studies above that bring benefits, namely being able to improve students' critical thinking skills by using the Discovery learning model, it is very important to conduct further meta-analysis research, therefore the researcher is interested in conducting meta-analysis research.

## Method

### *Research Methods and Design*

Meta-analysis is a systematic review method accompanied by statistical techniques to calculate the conclusions of several research results (Mancin et al., 2024). Meta-analysis research is also called meta-research. This research uses libraries, books, or journals as data sources. The method used in this study is meta-analysis, namely a quantitative statistical review or systematic review by analyzing research results that have been published internationally related to the meta-analysis of the use of the Discovery Learning model on students' thinking skills.

### *Population and Sample*

The population is all research subjects. Population is a generalization area consisting of objects that have certain qualities and characteristics determined by researchers to be studied and then conclusions drawn. The population in this study is an educational journal article related to the effectiveness of using the Discovery Learning model on high school students' critical thinking skills in social studies subjects that have been published. The sample is part of the number and

characteristics of the population. The sample is part or representative of the population being studied. The sample is part of the population for the data source. The sample in this study is an article in a journal that has been published internationally related to the effectiveness of using the Discovery learning model on critical thinking skills of high school students in the period 2017 - 2022.

*Research Instrument*

The tool used to collect the desired data and information is called a research instrument. The instrument used in this study is a coding sheet (data coding). The variables used for coding in collecting information on the effect size in meta-analysis research as conducted by Kadir, namely article data consisting of researcher's name, research title, journal name, and year of publication; sample characteristics in the form of research location, research subjects, and research samples; variables, designs, and instruments in the form of independent and dependent variables, research design and hypothesis testing; experimental and control class learning interventions; effect size and average effect size. The steps of meta-analysis research according to (Tawfik et al., 2019), are determining research questions, determining relevant research, coding, calculating effect size, and converting effect size values.

*Research Stages*

The research stages for meta-analysis generally consist of five processes, namely defining the problem collecting available literature, converting and correcting statistical information, determining the average of the data obtained, and considering variations in the effects that have been observed. The stages that will be carried out in this study are the first is to determine the problem or topic to be studied regarding the effectiveness of the use of Discovery learning on the results of students' critical thinking skills. Second, searching for and collecting research articles in the form of international

journals related to the problem or topic to be studied and determining the period of research findings that are used as source data, namely published in 2017-2022. Third, reading research reports to adjust the content to the problems that have been determined, focusing research on problems in the form of aspects of research methodology and categorizing each study or recording as much information as possible from research reports. Fourth, determining the effect size of each study from each of those obtained. Fifth, analyzing published research reports based on the study of the methods and data analysis used, so that conclusions can be drawn from the meta-analysis conducted.

*Data Collection*

Data collection is carried out by searching for articles that are relevant or related to the topic to be studied. Articles collected from Scopus journals from 2017 - 2022 obtained 230 articles and filtered those that were close to the title of our article, then obtained 4 journal articles. The data collected is research data that is by the required variables by the coding. The results of the data are then divided according to groups based on data on the average sub-research of each experimental group and control group and the standard deviation of each sub-research.

**Result and Discussion**

*Data Analysis Techniques*

*Coding:*

The coding steps are carried out by selecting international journals that have the same bound indicators, namely students' critical thinking skills. The next stage is that we write the title of the journal, the name of the journal author, and the year the journal was published. After that the name of the journal, the country of origin of the author, and the research control class. Next, the skills achieved, the object of research, and the type of research.

**Table 1.** The Skills Achieved, the Object of Research, and the Type of Research

Journal Title	Author /Year	Journal Name	Country	Control Type	Skills	Object	Type of Research
Improving Students Critical Thinking Skills Through Student Worksheet Colloid Systems Representations at Senior High School	Rihayati, Sri Utaniningsih, Santoso/2020	Journal Of Physics: Conference Series	Indonesia	Conventional	Discovery learning improves critical thinking skills	High School Students	Journal
Combination of Discovery Learning and Metacognitive Knowledge	Elya Nusantari, Aryati Abdul, Insar Damopolli, Ali Salim Rasyid	Europen Jurnal of Educational Research	Indonesia	Conventional	Discovery learning. Strategies to improve	High School Students	Journal

Journal Title	Author /Year	Journal Name	Country	Control Type	Skills	Object	Type of Research
Strategy to Enhance Students Critical Thinking Skills	Algafri, Bakkar Suleiman Bakkar/2021				critical thinking skills.		
Development of Students Critical Thinking Skills Through Cuided DL (GDL) and Problem-Based Learning Models (PBL) in Accountancy Education	Mardi, Achmad Fauziz, Dwi Kismayanti Respati/2020	Eurasian Journal of Educational Research	Indonesia	Conventional	Discovery learning to develop Critical Thinking	High School Students	Journal
Critical Thinking Skills of Environmental Changers: A Biological Instruction Using Guided DL-Argument Mapping (GDL-AM).	Rizhal Hendi Ristanto, Arin Sabrina Ahmad, Ratna Komala/2022	Participatory Educational Research	Indonesia	Conventional	Guided discovery learning to Improve Critical Thinking	High School Students	Journal

*Finding the Effect Size*

The next step is to find the effect size by finding the research sample (n), average, and standard deviation (S), then the standard deviation is squared  $[(s)]^2 = \sqrt{x}$ . Both in the experimental class and the control class. The next step is to find the Swith in or combined standard deviation of the experimental group and the control group. Finding, the average difference between the experimental class and the control class, namely d = Average difference.

$$\text{Formula} = \bar{X}_1 - \bar{X}_2 \tag{1}$$

$$\text{Calculating the standard error or Vd} = \frac{n_1+n_2}{n_1n_2} + \frac{d^2}{2(n^1+n^2)}$$

Description:

$n_1$  = Number of experimental group samples

$(X_1)^{\bar{}}$  = Average of the experimental group

$s_1$  = Standard deviation or standard deviation of experimental group  $[(S_1)]^2 = S_1$  squared

$n_2$  = Number of control group samples

$(X_2)^{\bar{}}$  = Average of control group  $[(S_2)]^2 = S_2$  squared

Swith in = Combined standard deviation of experimental and control groups.

$$\text{Formula} = \text{Swith in} = \sqrt{((n_1 - 1)S_1)^2 + ((n_2 - 1)S_2)^2} : (n_1 - 1) + (n_2 - 1) \tag{2}$$

d = Average difference -average,

$$\text{Formula} = (X_1)^{\bar{}} - (X_2)^{\bar{}} \tag{3}$$

Swithiin Vd =  $\sqrt{((n_1+n_2)/(n_1n_2)) + (d^2/(2(n^1+n^2)))}$   
 $df = n_1 + n_2 - 2$   $J = 1 - \alpha(3/(4df-1)) = g = J \times d = \text{Effect Size}$   
 $Vg = J \times Vd = \text{Variant Effect Size}$   $SEg = \text{Standard error Effect Size}$

$$\text{Formula} = \text{Swith in} = \sqrt{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2} : (n_1 - 1) + (n_2 - 1) \tag{4}$$

**Table 2.** Effect Size Categories in General

Effect Size	Description
$g < 0.10$	No effect
$0.10 \leq g < 0.40$	Small
$0.40 \leq g < 0.80$	Medium
$g > 0.80$	Large

The effect size categories are as follows:

**Table 3.** Effect Size Value Category

Effect Size	Category
$ES < 0.20$	Ignorable
$0.20 \leq ES < 0.50$	Medium
$0.50 \leq ES < 0.80$	Large
$ES \geq 0.80$	Very Large

Based on the findings of the meta-analysis of articles related to students' critical thinking skills that have been carried out, it shows that students' critical thinking skills are in a low category after the research action and analysis shows that the level of students' critical thinking skills has increased after the implementation of the Discovery Learning model in

learning. This journal shows that the Discovery Learning model can improve students' critical thinking skills with

an average effect size value of 18.89 with a very large category.

**Table 4.** Effect Size

Exp		Control		Ctl												
$n_1$	$\bar{x}_1$	$s_1$	$s_1^2$	$n_2$	$\bar{x}_2$	$s_2$	$s_2^2$	Switch in	d	Vd	Df	J	g(ES)	Vg	Seg	
26	79.21	2.83	8.00	42	67.04	2.24	5.01	14.41	12.17	2.72	66	0.06	0.76	0.17	2.23	
32	82.82	4.28	18.38	59	50	3.94	15.52	0.27	-32.82	0.20	89	0.99	32.54	1.01	0.18	
10	87.80	12.74	162.30	30	47.60	12.74	162.30	10052.31	40.20	1.02	38	0.80	32.32	0.82	0.37	
33	53.24	12.33	152.02	33	63.30	9.79	95.84	5.16	10.06	0.13	64	0.98	9.94	0.13	2.64	

Researchers have a view to overcome these learning problems, namely by choosing the right learning model to overcome the problem, namely the Discovery learning model because this model is discovery learning. The Discovery learning model according to J. Brunner is a learning model that has three stages, namely the information stage, the transformation stage, and the evaluation stage (Verhoef et al., 2021; Baumgartinger-Seiringer et al., 2021). In the transformation stage (material transformation stage), information is analyzed, changed, and transformed into a more abstract or conceptual form. By using this model, students will be trained to think critically. This is by the aspect of critical thinking, namely thinking deeply so that students find findings in the form of relevant, valid information and can build generalizations.

Discovery Learning makes learning more meaningful so that it is well embedded in students' knowledge (Utomo et al., 2023; Wang et al., 2023). By innovating the Discovery learning model, it is considered capable of overcoming the weak critical thinking skills of students in social studies subjects. In practice, learning is carried out according to the syntax of the Discovery learning model. The role of the teacher as a facilitator is to direct learning with techniques that support critical thinking skills, namely by directing and guiding students to think deeply, namely by collecting relevant data and analyzing a problem from various social science or social studies perspectives (Safitri, 2023). Discovery learning is based on constructivist learning theory. Therefore, in discovery learning, students construct knowledge based on new information and data collected by them in an exploratory learning environment. (Syolendra & Laksono, 2019). The development of learning models needs to be carried out to achieve learning objectives, especially those that can overcome student misconceptions (Darling-Hammond et al., 2020; Kamalov et al., 2023). The syntax of the learning model according to Eriza et al. (2023) Consists of Providing Stimulus (Stimulation), Problem statement (providing Problem Focus), Data collection, Data processing, Proof or verification, and Conclusion or generalization.

The characteristics of the Discovery Learning model are exploring and solving problems to create, combine, and generalize knowledge, student-centered, and activities to combine new knowledge with existing knowledge (Wilkie, 2024). Discovery learning according to Karpinski et al. (2018), discovery learning is actively seeking knowledge to solve problems and the knowledge that accompanies it to produce meaningful knowledge. The definition of the discovery learning model is a model that is based on student activities to think and analyze so that students can find or acquire knowledge and skills independently (Muhali & Sukaisih, 2023). The advantages of the Discovery Learning model include: The advantages of Discovery Learning according to Kay et al. (2016), are many advantages in implementing Discovery Learning, including strengthening students' self-confidence that they can find their theories, concepts, rules, or principles in learning. The above is supported by a research journal entitled: The Effect of Discovery Learning Model on Students' Critical Thinking and Cognitive Ability in Junior High School written by Ekayanti et al. (2022) which states that the critical thinking skills of students who are taught with Discovery learning are better than students who are taught with conventional learning,

The Discovery Learning Method for Training Critical Thinking Skills of Students was written by Muliati et al. (2020), which stated that the application of the discovery learning method in the learning process can train students' critical thinking skills because what is found in the search process will be better remembered and easier to form an understanding; Development of Local Wisdom-Based Discovery learning Model to Improve Critical Thinking Skills of Theme Growth and Development of Life written by Hakim et al. (2018) Which states that the development of a discovery learning model is one of the learning methods according to the needs and problems faced by teachers and students to improve student's critical thinking skills; Application of The Discovery Learning Model to Improve Critical Thinking Ability in Vibration and Wave Materials written by Palinussa et al. (2023) Which states that the application of the Discovery Learning learning model can improve students' critical thinking

skills in science subjects in junior high schools; Analyzing The Contribution of Critical Thinking Skills And Social Skills on Students' Character by Applying Discovery; earning models written by Koten et al. (2024), states that critical thinking skills have a significant relationship with students' character in the application of the Discovery learning model, the Discovery Learning model can be used as an alternative learning model to improve students' critical thinking skills.

## Conclusion

From the results of the journal analysis, because the effect size results are greater than 0.8, it means that it has a large influence, namely the influence of the independent variable on the dependent variable, namely effectively influencing. The theory that we can develop is that the Discovery learning model can influence critical thinking skills or effectively improve students' critical thinking skills.

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## Author Contributions

Conceptualization; S. H. R.; methodology.; A.; validation; G., formal analysis; M. R.; investigation.; S. H. R.; resources; A.; data curation: G.; writing—original draft preparation. M. R.; writing—review and editing: S. H. R; visualization: A. All authors have read and agreed to the published version of the manuscript.

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## Conflicts of Interest

The author hereby declares that he has no personal interests whatsoever that may influence the representation or interpretation of the reported research results.

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