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META-ANALYSIS STUDY OF THE EFFECT OF GUIDED INQUIRY MODEL ON CRITICAL THINKING SKILLS OF STUDENTS SCIENCE CONCEPTS

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Abstract

The development of education in the 21st century requires educators and students to be able to improve critical thinking skills. The process of improving critical thinking skills requires a learning model, one of which is through a guided inquiry model. The application of the inquiry model is able to train students to have the ability to think about something new so that they can solve students' own concepts or ideas. The purpose of this study was to analyze the effect of the guided inquiry model on students' critical thinking skills. Data collection techniques were carried out by browsing various articles related to the inquiry model and critical thinking skills through Google, Google Scholar, and Scopus. The search results obtained 35 articles or related journals. Data analysis technique was carried out in a quantitative descriptive manner using the help of *Microsoft Excel* and *JASP applications*. The results showed that the results of the analysis using the random *effect* had a significant positive effect or correlation between the guided inquiry model on students' critical thinking skills in science lessons. The results of the *egger test* and *fail safe N* analysis show that there is no publication bias in the meta-analytical studies discussed, so that the analyzed meta-analytical studies can be scientifically justified.

Keywords**:** *Guided Inquiry Model, Critical Thinking Skills, and Science Lessons*

INTRODUCTION

The 21st century is referred to as the century of knowledge, the age of knowledge-based economy, the century of information technology, the century of openness or globalization, the industrial revolution 4.0 and so on. In this century, human life undergoes fundamental changes that are different from the order of life in the previous century. Humans in the 21st century must master science, have metacognitive skills, be able to think critically and creatively, and be able to

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communicate or collaborate effectively, this situation illustrates the gap between expectations and reality. The preparation of human resources who master 21st century skills will be effective if taken through education. Critical thinking is part of 21st century learning skills. Critical thinking consists of the ability to think logically, reflectively, and productively to assess situations in making the right decisions (Andayani et al., 2019)

Critical thinking is an act of active thinking that leads students to be able to conceptualize, apply, analyze, synthesize, and evaluate rather than just accepting ideas or information. Students find it easier to think deeply about existing problems. Especially about fundamental life issues (Ennis, 1993; Hakim et al., 2018; Sellars et al., 2018; Sumarni & Kadarwati, 2020). Critical thinking is included in the realm of higher-order thinking skills that have the potential to increase students' critical analysis power. Increasing students' critical analysis power is closely related to increasing students' intellectual abilities (Setiawati et al., 2017).

HOTS is defined as an ability that involves critical and creative thinking to solve a problem. Someone with high-order thinking skills must be able to analyze, connect, parse and interpret problems to obtain new solutions or ideas. HOTS itself is part of the cognitive domain in the revised Bloom's Taxonomy. HOTS is at the level of analyzing, evaluating to creating (Saraswati & Agustika, 2020).

One of the lessons that must be improved in the process of thinking skills and independent learning of students is in the form of science learning. As explained that science is the science of objects and natural phenomena obtained from the thoughts and research of scientists carried out with experimental skills using the scientific method. The nature of science is the foundation for studying science (Tursinawati, 2016). This science learning needs an encouragement or an educator who is able to improve student understanding for the better, namely a professional teacher.

Critical thinking skills are students' cognitive processes in analyzing systematically and specifically the problems encountered, distinguishing these problems carefully and thoroughly, as well as identifying and reviewing information in order to plan problem solving strategies (Azizah et al., 2018). Critical thinking skills in the learning process are very important, so educators must create learning activities that are able to encourage students to be active and creative.

Critical thinking skills will not be strong if they do not go through a process until students are able to survive in confusion and uncertainty to arrive at the stability of these skills (Nuraeni et al., 2019). Critical thinking skills are one of the higher-order thinking skills that require students to use cognitive levels at the levels of analysis, evaluation, and creation (Hidayati et al., 2019).

The best critical thinking skills can be done by linking learning materials and students' real experiences in their everyday environment, so that in the 2013 curriculum learning it is necessary to design learning strategies that allow the development of students' critical thinking skills (Susilawati et al., 2020).

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Students' critical thinking skills provide encouragement in students to think for themselves, question hypotheses, analyze and synthesize events to go further by developing new hypotheses and testing them against facts (Karakoc, 2016).

Critical thinking in the form of thinking that involves reasoning and logic to solve problems (Fuad et al., 2017). Critical thinking is proven to prepare students to think in various sciences, for intellectual self-fulfillment and to develop students as potential individuals, thus critical thinking skills can be developed in learning (Zain & Jumadi, 2018).

The results of the literature study prove that students' critical thinking skills are closely related to the development process of the 21st century and the implementation of the 2013 curriculum. Students in the 21st century must be able to develop critical thinking skills, so a learning process is needed that is able to support its implementation. The results of the study of several previous studies suggest that the implementation of learning still tends to be conventional which is dominated by the lecture and question and answer method (Sutama et al., 2014; Syafaren et al., 2019; Asiah, 2021). In addition, the teacher gives students a lot of group assignments so that learning involves discussion activities, but students rely heavily on existing textbooks and do not explore other sources much (Maryam et al., 2020). Students only solve problems that are exactly the same as the examples given, so they have not been able to solve analytical questions (Jayanti & Amin, 2018; Cahyati & Subali, 2022).

The learning problems faced by these students are caused by the low critical thinking skills of students. This is because the application of the learning model does not provide opportunities and learning experiences to construct scientific concepts that are learned through the thinking process. One of the solutions provided by previous studies is through a guided inquiry model that is able to improve students' critical thinking skills.

Ichsan et al. (2019) says that in simple terms the learning model is a model consisting of certain phases or syntax that can direct students to learn, so as to achieve learning objectives. Therefore, one of the learning models that can achieve student learning goals is inquiry learning. This is in accordance with the opinion expressed by Sitorus et al. (2017) that the inquiry learning model is able to motivate and encourage students to be active in exploring and mastering the subject matter itself. Inquiry-based science learning has been shown to have the potential to increase student involvement in science at all levels as well as competency development (Boaventura & Faria, 2015). The guided inquiry learning model is a learning model that emphasizes the process of finding concepts and relationships between concepts, where students design their own experimental procedures, so that the student's role is more dominant, while the teacher only guides students in the right direction (Laila & Lufri, 2019). Inquiry learning is able to instruct an active learning process that reflects a scientific approach in investigating and investigating science learning (Dostal, 2015).

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The guided inquiry model can increase student learning creativity because students have the ability to think about something new so they can solve problems and are able to develop students' own concepts or ideas (Zulvawati, 2019). Guided inquiry learning model is a teaching model that emphasizes the process of finding concepts and the relationship between concepts in which students design their own experimental procedures so that the role of students is more dominant, while the teacher guides students in the right direction (Laila & Lufri, 2019).

The results of the study of several literatures prove that the guided inquiry learning model encourages students to be active in learning. Student learning activities can affect the improvement of students' critical thinking skills, so as an educator it is necessary to apply a learning model that is in accordance with the material being taught. Based on some of the problems that have been discussed previously, the purpose of this study is to conduct a meta-analysis of the influence of the guided inquiry model on students' critical thinking skills in science lessons.

METHODS

The approach used in this research is a quantitative descriptive approach. Putra (2013) said that quantitative descriptive research aims to see, review and describe numerically the object under study as it is and draw conclusions about it according to the phenomena that appeared at the time the research was conducted. This type of research is a meta-analysis by collecting data from the results of previous studies.

The instrument used in the meta-analysis research was carried out with the coding category. The coding is divided into two parts, namely: the section that provides information codes related to the empirical findings of the study (effect size) and the section that provides codes related to information on study inclusion criteria. The use of effect size (ES) has a relationship with meta-analysis. Because the interpretation of the influence between the dependent variable and the independent variable, and its value can only be compared between studies with the acquisition of the ES value.

To obtain data, the researchers conducted a search through *Google, Google* or *Google Scholar,* and *Scopus*. This meta-analysis study which discusses the effect of guided inquiry models on improving students' critical thinking skills in science lessons (science, physics, chemistry, and biology) at the elementary, junior high, high school and college levels consists of 35 articles or journals in 2014- 2022. The data obtained were presented in a quantitative descriptive manner which was analyzed through the help of *Microsoft Excel* and JASP applications.

RESULTS AND DISCUSSION

Based on the results of a study of 35 (thirty five) articles or journals that were explored, several tests could be carried out to determine whether the guided inquiry model overall had an effect on increasing students' critical thinking skills in science lessons. In the early stages of analysis, the researcher collected data from the experimental class and the control class, which consisted of the mean, standard

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deviation, and number of samples (n). Then from the data the two classes are mapped to determine the *Standard Error* and *Effect Size*. The second stage was analyzed using the JASP application to find out whether the mapped data had an effect or a significant relationship or not. The JASP analysis was carried out by analyzing the heterogeneity test, Summary Effect or Mean Effect Size, Forest Plot, and Funnel Plot. The results of the analysis can be interpreted as follows.

1. Heterogeneity Test Analysis

Heterogeneity is defined as the difference in methodology or research characteristics used by several studies. Heterogeneity in the meta-analysis is problematic when there is more heterogeneity than the sampling variation in the study. If ignored, it can cause *underestimate*. Sources of heterogeneity can arise through the study design and various other forms of bias from the results obtained. Heterogeneity may arise from systematic differences between studies or random differences between *effect sizes,* or both. If heterogeneity is caused by random differences, it can be modeled. Based on the results of data analysis, the results of the heterogeneity test can be seen in table 1.

Table 1. Heterogeneity test analysis

Fixed and Random Effects	Q	Df	P
Omnibus test of Model Coefficients	27,286	1	<0,001
Test of Residual Heterogeneity	446,455	34	<0,001

Note. p -values are approximate
Note. The model was estimated using Restricted ML method.

Based on the results of data analysis in Table 1, it shows that of the 35 effect sizes the studies analyzed were heterogeneous (Q=446.455, *p* <0.001). Thus, the random *effects* is more suitable for estimating the mean *effect size* of the 35 studies analyzed. The results of the analysis also indicate that there is potential to investigate moderating variables that influence the relationship between the guided inquiry model on improving students' critical thinking skills in science lessons.

If the heterogeneity test shows the data in heterogeneous form, then the random effects model can be applied. The disadvantage of using this model is because the statistical test power is low, so it fails to show a significant difference even though there is a difference. As explained by Akbar & Yudiarso (2020) that using a random effect model is also based on differences in measuring instruments and subject characteristics in the studies used.

2. Summary Effect/ Mean Effect Size

After the effect size, variance, and standard error of the effect size have been obtained, the analysis procedure is continued by calculating the *summary effect*. *Summary effect* is calculated to find out a summary or general description of the *effect size* to be observed. To calculate the *summary effect size*, of course, it is not possible to directly average the *effect size* of all analyzed studies. This is because the

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analyzed studies have diversity, especially in terms of sample size and characteristics. This diversity needs to be taken into account in making a summary effect (Retnawati et al, 2018). The results of the analysis can be seen in table 2.

Table 2. Summary effect/ mean effect size

	Coefficients				95% Confidence Interval	
	Estimate	**Standart Error**	**Z**	**P**	**Lower**	**Uppar**
Intercept	1,041	0,1999	5,224	<0,001	0,650	1,431

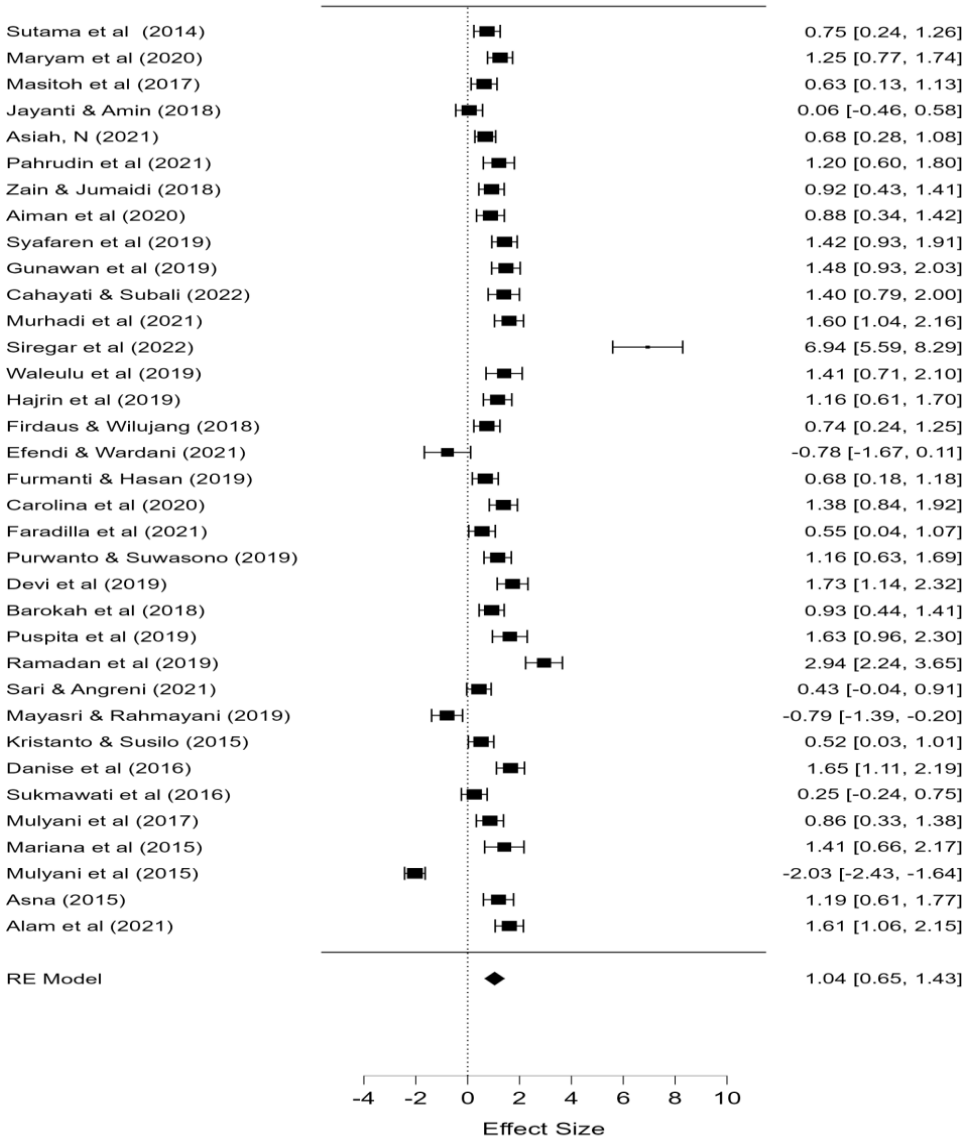

Figure 1. Forest plot results

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Based on table 2 shows that the results of the analysis using the random effect model there is a significant positive effect or correlation between the guided inquiry model on students' critical thinking skills in science lessons with a value (z = 5.224; p < 0.001; 95%CI (0.650; 1.431)). The influence of the guided inquiry model on students' critical thinking skills is included in the high category ($r_{estimate}$ = 1.041). Cohen (1988, 1992), the effect size is low if the value of r varies by about 0.1, moderate if r varies by about 0.3, and large if r varies by more than 0.5. This proves that the guided inquiry model is able to influence the improvement of critical thinking skills. As the results of previous research conducted by Wartini (2021) that the guided inquiry model is able to improve students' critical thinking skills because this learning model can train students to learn to find problems, collect, organize, and solve problems.

3. Forest Plot

The graphical method used to visually display the results of the meta-analysis is the *forest plot*. *Forest plots* allow the results of all studies at a glance and provide an estimate of *effect size* with appropriate confidence intervals (Khalimah, 2015). The forest plot graph can be seen in Figure 1.

4. *Funnel Plot*

Traditionally, funnel plots are plotted from the effect size on the X axis and the sample size or variance on the Y axis (Retnawati et al., 2018). The funnel plot graphs in this meta-analysis are as follows.

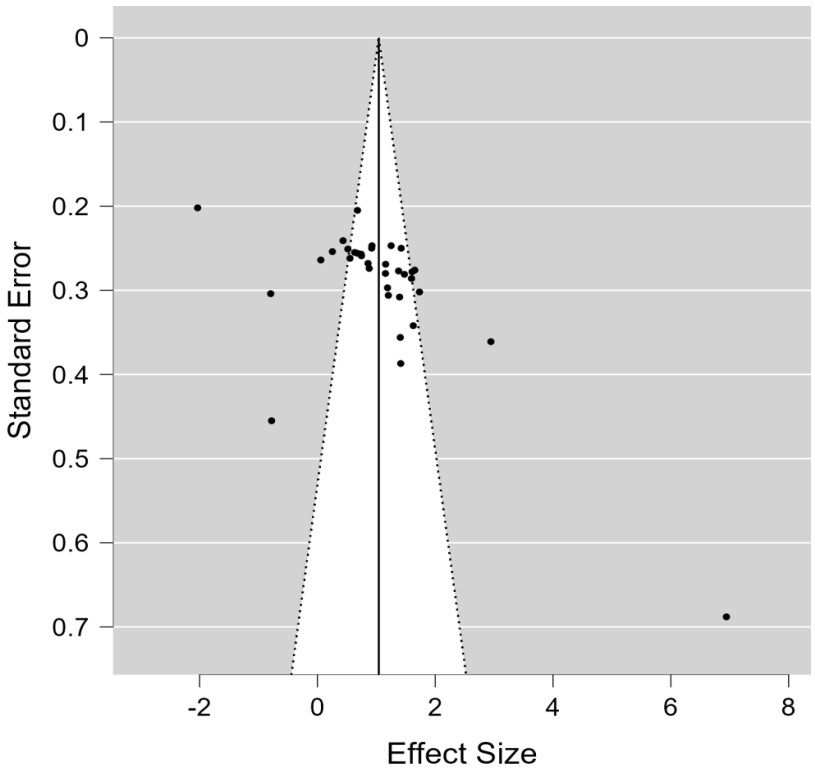

Figure 2. Funnel plot

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Figure 2 shows that the results of the funnel plot difficult to conclude whether the funnel plot is symmetrical or not, so it can be analyzed more clearly by the engger test. If it is symmetrical, there is no potential for publication bias. But this is not a strong evidence basis to know that the funnel plot is symmetrical or asymmetrical, so it requires an Egger test table to measure whether the funnel plot is symmetrical or not. The test results can be seen in table 3.

Table 3. Engger test

Regression Test for Funnel Plot Asymmetry ("Egger's test")		
	Z	P
Sei	5,095	<0,001

The results in table 3 show that the *p-value* < 0.001 or < 0.05, it can be estimated that *the funnel plot* symmetrical. Thus, it can be concluded that there is no publication bias problem in this meta-analysis research study. Furthermore, bias problems can also be identified through *fail safe N*, more details can be seen in table 4.

Table 4. Fail Safe N

le Drawer Analysis			
	Fail-safe N	Target Significance	Observed Significance
Rosenthal	4979,000	0,050	<0,001

Based on table 4, the value of fail safe N is 4979,000 with a target value of 0.05 significance and p < 0.001. Then because the K value is 35, 5K + 10 = 5(35) +10 = 185 indicates that the fail safe N value is > from 5K + 10, so it can be concluded that there is no publication bias in the meta-analysis study on the effect of guided inquiry models on skills. critical thinking discussed in this study. Therefore, this meta-analysis study can be justified scientifically.

CONCLUSION AND RECOMMENDATION

Based on the results of the meta-analysis of the influence of the guided inquiry model on critical thinking skills, it can be concluded that there is potential to investigate moderating variables that affect the relationship between the guided inquiry model to improve students' critical thinking skills in science lessons. The results of the analysis using the random *effect* have a significant positive effect or correlation between the guided inquiry model on students' critical thinking skills in science lessons. The results of the *egger test* and *fail safe N* analysis show that there is no publication bias in the meta-analytical studies discussed, so that the analyzed meta-analytical studies can provide scientific accountability. For further research, it is expected to use more data, as well as examine other variables, in order to find out the correlation as well as egger test and fail safe N on these variables.

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