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Meta-Analysis: The Effect of Learning Methods on Students' Critical Thinking Skills in Biological Materials

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Abstract

Critical thinking skills are important for students as they enable them to develop social, scientific attitudes and solve practical problems. This study aims to identify learning methods that can be used to develop critical thinking skills. This research method is a meta-analysis using articles obtained from online journal databases. Data were analyzed quantitatively by calculating the effect size. Based on the results of the study, it can prove that (1) critical thinking skills effective develop in high school students and (2) learning methods used to train students' critical skills are PjBL and GI.

Keywords: *meta-analysis, learning methods, critical thinking, biology*

Introduction

Thinking skills needed in the 21st century are critical thinking skills (Kharbach, 2012). Critical thinking as a whole involves reasoning. Muhfahroyin (2009) states that critical thinking is a process that involves mental operations such as induction deduction, classification, evaluation, and reason. The same thing was express by Fogarty and McTighe (1993), where critical thinking is a thoughtful way of thinking that makes sense or is base on an effective way of thinking that makes sense or is base on reason to do and believe.

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Savage (1996) and Zevin (2007) stated to achieve students' maximum competence in a topic. It is essential to empower critical thinking skills. According to Shakirova (2007), critical thinking skills are required for students because they enable them to develop social, scientific attitudes and solve practical problems. Simply put, students who can think critically can solve problems effectively.

Having knowledge or information is not enough. Students must solve problems to make effective decisions; therefore, students must think critically (Snyder & Snyder, 2008). Stephan (2004) states that if the ability to think critically is not using as an indicator of the educational process's success, it will impact students who often have difficulty identifying a complex problem. Seeing how important critical thinking is for students, many teachers are trying to develop critical thinking skills (Tempelaar, 2006). Somebody can integrate the development of critical thinking skills in the learning process (Snyder & Snyder, 2008)

The learning process cannot separate from the instructional design or learning methods used. Somebody can define learning methods as comprehensive methods (from beginning to end) in a systematic order based on a specific approach to achieve learning objectives (Zubaidah, 2010). The selection of learning methods adjusted to the material's characteristics, learning objectives, student characteristics, time allocation, and available infrastructure. The use of appropriate learning methods can support learning objectives optimally, including practicing critical thinking skills.

Several learning methods are reported to empower students' critical thinking skills, including the remap-CS method (Kurniawati, Zubaidah, & Mahanal, 2016), remap-RT (Sholihah, Zubaidah, & Mahanal, 2016), GI (Wijayanti, Herlambang, & Slamet , 2013; Suartika, Arnyana, & Setiawan, 2013; Anggraini, 2015) and guided inquiry (Aini, Ramdani, & Raksun, 2018; Nurmayani, Doyan, & Verawati, 2018; Amijaya, Ramdani, & Merta, 2018; Nurhidayati, Zubaidah , & Indriwati, 201; Kristanto & Susilo, 2016), inquiry (Sutama, Arnyana, & Private, 2014; Masitoh & Ariyanto, 2017; Anggareni, Ristiati, & Widiyanti, 2013), PBL (Fitriyani, Corebima, & Ibrohim, 2015 ; Kono, 2016; Hadi, 2013), PjBL (Insyasiska, Zubaidah, & Susilo, 2017; Riyadi, 2019; Meriani, Khairil, & Kasmirudin, 2019; Setiawan, 2010), PBT (Muskitta & Djukri, 2016), Mind Map and Question Student Have (Khoiriyah, Suratno, & Murdiyah, 2015), discovery learning (Utami, 2017; Ikalor, Jamaluddin, & Rasmi, 2019). Determining the right method to practice critical thinking skills needs to be done so that the empowerment of thinking skills can be done optimally. This can be done by conducting a meta-analysis

Meta-analysis is a quantitative technique that uses a specific measure (for example, the size effect) to show the strength of a variable relationship (Shelby & Vaske, 2008; Duveneck, 2015; Guzzo, Jackson & Katzell, 1987). This technique compares the results of various studies on a specific issue. Research on meta-analysis has been carried out on several topics, including learning media in biology learning (Chandra, 2011; Surata, Sudiana, & Sudirgayasa, 2020; Nadhifah & Agustin, 2020), motivation and learning achievement (Adiputra & Mujiyati, 2017), learning approaches (Aulia, Zarkasih, & Nova, 2020), the effectiveness of guided inquiry models on science process skills and students' critical thinking skills (Kurniawti, Festiyed, & Asrizal, 2019); the relationship of critical thinking skills with cognitive learning outcomes in several learning models (Kusniawati, 2019). A meta-analysis shows the relationship between learning methods and students' Critical Thinking Ability. It has also been carried out, for example, the use of the PjBL in SMA (Anggreni, Festiyed, & Asrizal, 2019), inquiry (Susilowati, 2020), discovery learning for SD (Noviyanto, & Wardani), 2020), PBL in mathematics (Phasa, 2020) and at the elementary level (Anugraheni, 2018; Febrina & Airlanda, 2020), and cooperative learning in physics (Syafrial, (2018). However, specific research focuses on comparison; various learning methods to empower students 'critical thinking skills in high school biology or junior high school science subjects are still rarely done. While the level is a crucial point where students' critical thinking skills can be developed and optimized.

Therefore this research aims to describe the learning methods used in developing critical thinking skills. Besides, this study's result also can be used as a reference for teachers in determining appropriate learning methods and the direction of school policies in developing students' critical thinking skills. These findings can also be a reference for future researchers who have the same concerns about this topic.

Method

This research method is a meta-analysis by reviewing several articles in national journals. This research is a quantitative study with numerical and statistical calculations for practical purposes (Glass, 1981). This meta-analysis research uses 6 sample articles from national journals on learning methods for critical thinking skills. The distribution of the research subjects' themes can be seen in the groups in Table 1 as follows.

Table 1. Article Distribution

Information	Educational Stage	Learning Methods
Junior High School	3	
Senior High School	3	
PjBL		1
Inquiry		1
PBT		1
GI		1
Mockups and Discovery Learning		1
Mind Map and Question Student Have		1

The data tabulation steps are as follows.

1. Identification of research variables
2. Identification of means (control group and experimental group) and standard deviation
3. Calculation of the effect size
4. Determine the criteria for the effect size. The calculation of the effect size uses the formula Glass et al., (1981). The measure was done by dividing the mean of the experimental group and the control group's mean with a standard deviation. Somebody can see the formula for calculating the effect size criteria in Table 2.

$$\Delta = \frac{\bar{x}\ experiment - \bar{x}\ control}{SD\ control}$$

Table 2. Effect Size Criteria

Criteria	Effect Size
effect size < 0,15	Can be ignored
0,15 < effect size < 0,40	Low
0,40 < effect size < 0,75	Moderate
0,75 < effect size < 1,10	High
1,10 < effect size < 1,45	Very high
0,45 < effect size	Very High Impact

Results

Based on a study of six articles, the following effect sizes do obtain.

1. The magnitude of the influence of the learning method on students' critical thinking skills on biology material based on education level can be seen in Table 3.

Table 3. Effect Size Based on Education Level

Education Level	Δ	Category
SHS	1.79	Very high
JHS	0.54	Moderate

The meta-analysis's of learning methods on students' critical thinking skills on biology material based on education level shows that the effect size at the high school level was high, while at the junior high school level showed intermediate results. Various methods to train critical thinking skills are more effective at the high school level.

2. The magnitude of the influence of the learning method on students' critical thinking skills in biology material can be seen in Table 4.

Table 4. Effect Size based on the Learning Method

Learning Method	Δ	Category
PjBL	4,24	Very high
Inquiry	0,72	Moderate
PBT	0,42	Moderate
Mockups and Discovery Learning	0,03	Ignored
Mind Map and Question Student Have	0,36	Small
GI	1,23	Very high

The meta-analysis of the effect of learning methods on students' critical thinking skills on biology material shows the PjBL and GI methods have the largest effect size, inquiry and PBT have moderate effect size, student question has small, discovery learning has an effect size. Lowest so negligible. Based on this, it can be concluded that PjBL and GI can be recommended to practice critical thinking skills.

Discussion

Various learning methods can be used to train students' critical thinking skills. Based on the subject of differences in education levels, the study's findings showed that practicing students' critical thinking skills effectively applied the high school level than junior high school. Following the results of Supriyati et al. (2018), the high school critical thinking skills category of high school students is high, while the junior high school level is in a low sort (Hidayanti, 2016; Saputra, Hidayat, & Munzil, 2016). Peter (2012) states that the low critical thinking skills are due to lack of activity and training, limited resources, biased perception, time limiting environment in developing critical thinking skills. Carson (2007), Snyder and Snyder (2008), and Peter (2012) add that lack of prior knowledge results in students being unable to solve

problems. The size effect is very high at the high school level because students do not need to think with concrete objects or events. They can think abstractly. Students can understand the form of arguments and are not confused by the side of the discussion and therefore, it is called formal operational (Ibda, 2015).

PjBL Learning Method

PjBL can be used to empower critical thinking skills, as research conducted by Dimmitt (2017). PjBL is a model that uses contextual learning, where students play an active role in solving problems, making decisions, researching, presenting, and making documents. The learning model is designed to guide students in defining problems, exploring various issues, collecting relevant data, developing and testing hypotheses. This learning model trains students to build the ability to think independently and critically and teaches students to solve a problem in groups (Daniel, 2016). PjBL provides the opportunity to turn the classroom into a community of practice where students develop skills to become efficient researchers by leveraging technology. Apart from receiving intensive guidance from the teacher, students can collaborate with their classmates (Cash, 2017) to achieve the problem-solving process as an indicator of critical thinking.

GI Learning Method

The GI learning method is designed to guide students in defining problems, exploring various issues, gathering relevant data, developing and testing hypotheses. This learning model trains students to build the ability to think independently and critically and teaches students to solve a problem in groups (Wijayanti et al., 2013). The results of the meta-analysis conducted by Johnson, Johnson, & Stanne (2000) also show that GI has a high effect size. However, this rating is only suggestive. The small number of subjects in some methods makes the size effect very tentative. Besides, the measurement of critical thinking skills in various studies shows different results that can affect the size effect calculation.

Conclusion

The use of various methods to develop critical thinking skills is more effective at the SMA level. PjBL and GI can be used to develop students' critical thinking skills. Both methods have characteristics, including facilitating students in defining problems, exploring various issues, collecting relevant data, developing and testing hypotheses, making decisions based on the data analysis result, and compiling reports as the results of projects and investigations. Teachers can use both learning methods to develop critical thinking skills while still considering various things related to choosing the learning method. Suggestions for further research are to conduct a meta-analysis in an enormous scope, for example, comparing different cooperative learning methods about the development of metacognitive abilities or science process skills.

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