



## ASSESSING THE POTENTIAL OF OPEN-ENDED PROBLEM TO IMPROVE STUDENTS' CREATIVE THINKING SKILLS IN MATHEMATICS LEARNING

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### Abstrak

Penelitian ini dilakukan untuk mengukur potensi penggunaan *open-ended* dalam meningkatkan kemampuan berpikir kreatif siswa dalam konteks pembelajaran matematika. Metode penelitian yang digunakan adalah sistematis literature review dengan sumber data dari Google Scholar, Eric, DOAJ, Scopus, dan Science Direct menggunakan kata kunci "*open-ended problem*" dan "*creative thinking*". Hasil analisis data menunjukkan bahwa pemberian masalah terbuka berpengaruh positif pada kemampuan berpikir kreatif siswa. Literatur menyatakan hampir semua artikel mengakui bahwa masalah terbuka meningkatkan kemampuan berpikir kreatif siswa dalam pembelajaran matematika, bahkan pembelajaran berbasis masalah terbuka dapat lebih efektif. Kesimpulannya, soal terbuka berpotensi meningkatkan kemampuan berpikir kreatif siswa dalam matematika dan dapat dilatih melalui *Problem Based Learning* (PBL). Penelitian lanjutan dianjurkan untuk mendalami pengaruhnya secara lebih rinci.

**Kata kunci:** Berpikir Kreatif; Kajian Pustaka; Sistematis Pembelajaran Matematika; Soal Terbuka

### Abstract

This study was conducted to measure the potential use of open-ended in improving students' creative thinking skills in the context of mathematics learning. The research method used was systematic literature review with data sources from Google Scholar, Eric, DOAJ, Scopus, and Science Direct using the keywords "*open-ended problem*" and "*creative thinking*". The results of data analysis show that the provision of open-ended problems has a positive effect on students' creative thinking skills. The literature states that almost all articles recognize that open-ended problems improve students' creative thinking skills in mathematics learning, even open-ended problem-based learning can be more effective. In conclusion, open-ended problems have the potential to improve students' creative thinking skills in mathematics and can be cultivated through Problem-Based Learning (PBL). Further research is recommended to delve deeper into their influence.

**Keywords:** Creative Thinking, Mathematics Learning, Open-Ended Problem, Systematic Literature Review



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## INTRODUCTION

The typical approach to teaching mathematics involves instructing students with a specific method, after which they are expected to use it in solving analogous problems. In different nations, the process of acquiring mathematical knowledge frequently revolves around committing formulas or methods to memory (Xiao-hua, 2010; Hwang et al., 2015; Greeno, 2017). According to Bo et al. (2022), a teaching approach that solely focuses on instructing students to apply a specific method discourages them from utilizing innovative techniques. To put it differently, students tend to merely adhere to the instructions provided by their teacher rather than developing their own thought processes. Furthermore, presenting closed-ended problems to students results in uniform responses, restricting their creative thinking. In essence, education should empower students to approach problem-solving in their unique manner.

Creative thinking skills provide opportunities for students to express their own imagination/ideas when solving problems so that they become resourceful mathematical thinkers. Students who can become resourceful mathematical thinkers are the ideals of a powerful mathematics classroom (Schoenfeld, 2019). Furthermore, creative thinking skills are one of the most important skills in the 21st century (Piiro, 2011; Hendriyani et al., 2022). Creative thinking, one of the demands of Industry 4.0 and Society 5.0, can be reflected in students' creativity in mathematics because topics in mathematics have strong and relevant implications for social and everyday life (Kozlowski et. al, 2019).

Creative thinking skills basically refer to the skills to generate ideas that are new and have never been used before (Chavula et al., 2022). Creative thinking skills involve novelty, feasibility, and problems that are heuristic rather than algorithmic. Besides that, the problems given must be open-ended problems



(Siswono, 2017; Sa'idah et al., 2021; Rivera & Lugo, 2020). Creative thinking skills can be seen when students are able to solve problems by proposing new ideas or resolving a problem (Liljedahl and Sriraman, 2006; Dwi et al., 2022). Exactly, there are three components involved in assessing creativity: fluency, flexibility, and novelty (Silver, 1997). Creative thinking skills can arise when students solve problems in various ways and are original from their own minds. An example of problem that allows multiple ways is an open-ended problem. An open-ended problem is a problem that facilitates students to solve it in various ways and various solutions (Erhan & Bingölbali, 2021).

Providing open-ended problems gives students an opportunity to use their skills to dig up information, link it to related concepts, and solve the problem in their own way. When solving open-ended problems, students will struggle to find new paths, answers, and engage in creative thinking correctly. This process requires students to solve a problem with various ways of solving it. Open-ended problems require students' ability to think divergently, which is to produce different ways or different points of view from the same problem. Open-ended problems can be an option for teachers to improve students' creative thinking skills (Afandi & Jalal, 2017; Kozlowski et al., 2019; Rodriguez & Bonner, 2018; Septiani et al., 2022; Sonjaya & Yuliyanto, 2022). As Indah et al. (2018) study found that, learning based on open-ended solving problems can improve students' creativity in fraction material.

Based on literature, several studies state that there is a relationship between giving open-ended problems in mathematics learning and students' creative thinking skills. However, a study is needed to analyze the research that supports these results. Therefore, this research was conducted to look in depth at the results of research on giving open-ended problems to students' creative thinking skills.

## **METHOD**

This study uses a Systematic Literature Review (SLR) method, which is a survey-based quantitative descriptive approach (Little, 2008). The procedure for



carrying out a systematic literature review consists of 8 stages, namely: “formulating the research problem; developing and validating the review protocol; searching the literature; screening for inclusion; assessing quality; extracting data; analyzing and synthesizing data; and reporting the findings” (Xiao & Watson, 2019). Data was obtained from various sources, namely Google Scholar, Eric, DOAJ, Scopus, and ScienceDirect using the keywords "Open-ended" and "creative thinking". The data obtained was quite large, so the data was reduced to 15 articles based on the inclusion criteria shown in table 1.

**Table 1. Inclusion and Exclusion Criteria**

No.	Criteria	Inclusion	Exclusion
1.	Time period	The last 10 years (2013-2022)	Outside these time period
2.	Study focus	Mathematics education	Other fields
3.	Research method	Quasi-experiment, Mixed-method	Other methods
4.	Sample	Student	Common people who have passed education
5.	Language	Indonesia or English	Others language

## RESULT AND DISCUSSION

The research data, namely articles regarding the administration of open-ended problems to improve students' creative thinking skills, were then selected based on the inclusion criteria set out in Table 1. The next step was to summarize the selected manuscripts based on several key information, namely: author, year of publication, level of education, number of research samples, research methods and designs used, and research results. The results of the summary of the manuscript can be observed in Table 2.

**Table 2. Summary of Selected Articles**

No.	Author	Year	Title
1.	Agustian et al.	2015	“Pengaruh Pendekatan Open Ended terhadap Kemampuan Berfikir Kreatif Matematis Siswa Sekolah Dasar Kelas V”
2.	Agustian, Sujana, & Kurniadi	2015	“Pengaruh Pendekatan Open-Ended terhadap Kemampuan Berpikir Kreatif Matematis Siswa Sekolah Dasar Kelas V”



3.	Ardiyanti, Suarjana, & Garminah	2013	“Pengaruh Model Pembelajaran Matematika Berorientasi Open-Ended Problem terhadap Kemampuan Berpikir Kreatif Siswa pada Mata Pelajaran Matematika kelas IV SD”
4.	Dwiantara & Masi	2016	“Pengaruh penggunaan pendekatan pembelajaran open-ended terhadap peningkatan kemampuan berpikir kreatif matematika siswa kelas XI IPA SMAN 2 kendari”
5.	Dwipayana & Diputra	2018	“Pengaruh Pendekatan Pendidikan Matematika Realistik Berbasis Open Ended terhadap Kemampuan Berpikir Siswa SD Kelas V”
6.	Fatah etc.	2016	“Open-Ended Approach: An Effort in Cultivating Students’ Mathematical Creative Thinking Ability and Self-Esteem in Mathematics”
7.	Ginting	2019	“Pengaruh Pendekatan Open-Ended terhadap Kemampuan Berpikir Kreatif Siswa dalam Mata Pelajaran Matematika di Sekolah Dasar”
8.	Islam, Budiyo, & Siswanto	2021	“The Analysis of Mathematical Creative Thinking Test Instruments on Open-Ended Problems with Ethnomatematic Nuances”
9.	Magelo, Hulukati, Djakaria	2020	“Pengaruh Model Pembelajaran Open-Ended terhadap Kemampuan Berpikir Kreatif Matematik Ditinjau dari Motivasi Belajar”
10.	Sonjaya & Yuliyanto	2022	“Open-Ended Approach to Improving Mathematics Creative Thinking Skills of Elementary School Students”
11.	Suriyani, Hasratuddin, & Asmin	2015	“Peningkatan Kemampuan Berpikir Kreatif Matematis dan Kemandirian Belajar Siswa SMP Ar-Rahman Medan Melalui Pembelajaran Open-Ended Berbasis Brain-Gym.
12.	Waluyo	2018	“Pengaruh Pendekatan Open-Ended terhadap Kemampuan Berpikir Kreatif Matematis Siswa Sekolah Dasar Kelas V”
13.	Waluyo & Surya	2017	“Pengaruh Pendekatan Open-Ended dan Gaya Belajar Siswa Terhadap Kemampuan Berpikir Kreatif Matematis
14.	Wanelly & Fauzan	2020	“The Analysis of Students’ Creative Thinking Skills in Solving Open Ended Questions in Terms of Gender”

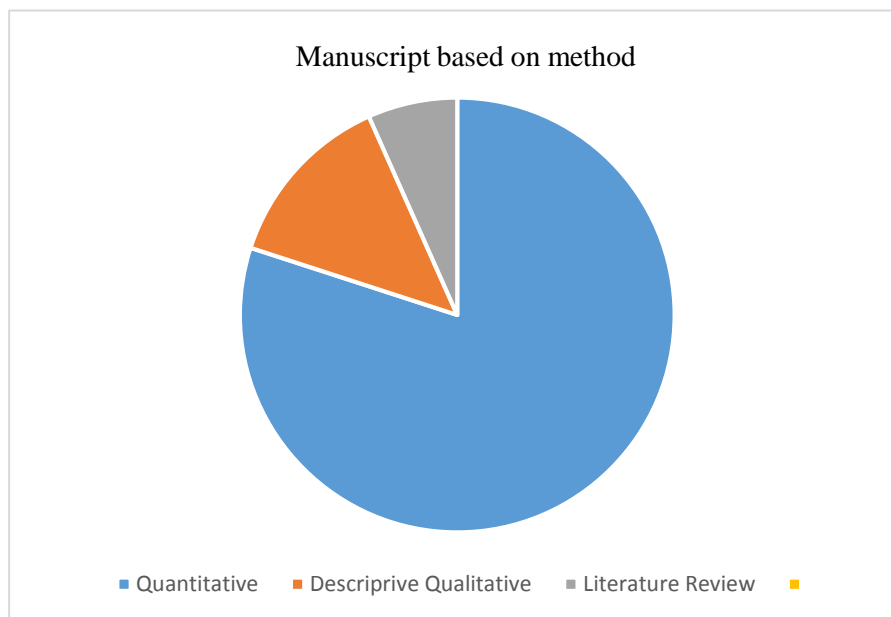


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15.	Yuniarti etc.	2017	“The Effectiveness of Open-Ended Problems Based Analytic-Synthetic Learning on the Mathematical Creative Thinking Ability of Pre-Service Elementary School Teachers”
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Based on table 2 above, it can be observed that there were 12 articles using quantitative research methods, 2 articles using qualitative descriptive methods, and one article using literature study methods. Thus, about 80% of the articles used quantitative research methods, 13.33% of the articles used qualitative descriptive research methods, and 6.67% of the articles used literature study research methods. Research using quantitative methods will answer whether there is an effect of giving open problems to student creativity, qualitative research methods described the profile of students' creative thinking skills when solving open problems, while research using literature study methods provide references to support the results of the research. A representation of the number of articles based on the research method is presented in figure 1.



**Figure 1. Selected Articles Based on Research Methods**

Furthermore, all research using quantitative methods uses quasi-experimental types and is divided into several research designs. The quantitative research design consisted of 8 pretest-posttest control group design articles, 3 non-

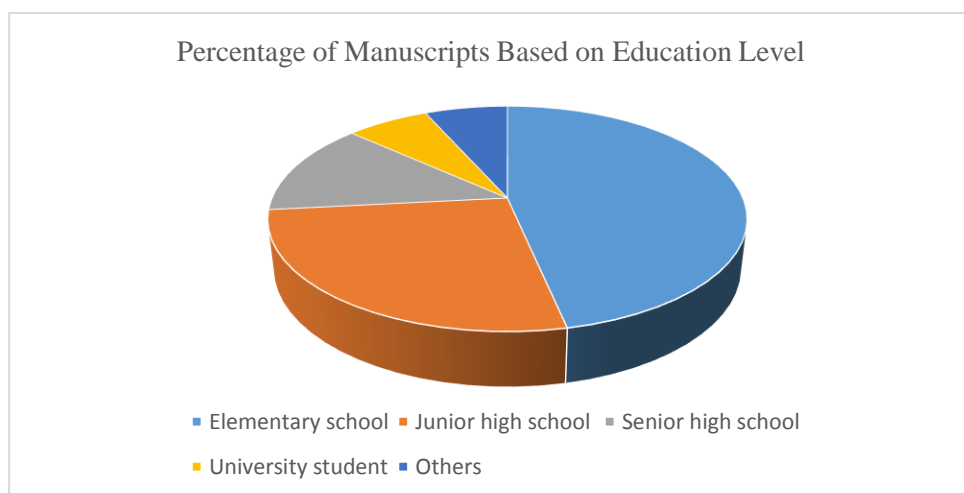


equivalent post-tests only control group design articles, and 1 article using a treatment design by level 2 x 2.

Research on the use of open problems in learning mathematics to improve students' creative thinking skills was conducted at various levels of education, starting from elementary school, junior high school, and senior high school. In detail, the percentage of research based on educational level is presented in table 3 and figure 2.

**Table 3. Percentage of Manuscripts Based on Education Level**

Level Pendidikan	Amount	Percentage
Elementary School	7 articles	46.67%
Junior High School	4 articles	26.67%
Senior High School	2 articles	13.33%
University Student	1 article	6.67%
Others	1 article	6.67%



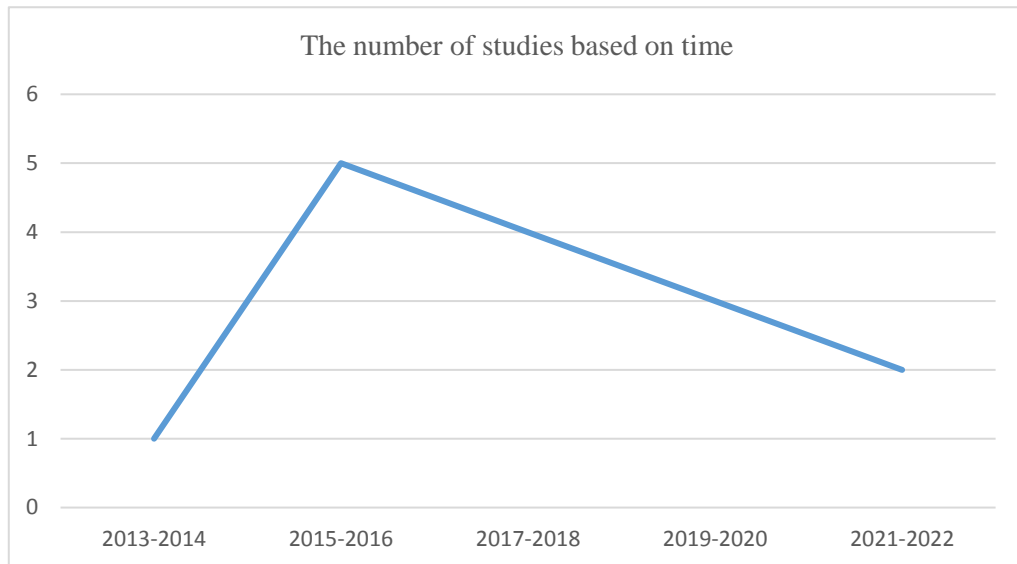
**Figure 2. Percentage of Manuscripts Based on Education Level**

Based on table 3 and figure 2, it appears that research on the effect of giving open-ended problems to improve students' creative thinking skills is spread across all school levels from elementary school to tertiary level.

The research was grouped based on the time span of each of the two years, namely: 2013-2014, 2015-2016, 2017-2018, 2019-2020, and 2021-2022. This grouping is done to see research trends regarding the provision of open-ended



problems on students' creative thinking skills in learning mathematics. The representation of these groupings can be observed in Figure 3.



**Figure 3. The Number of Studies Based on the year of Publication**

Sample size is used to ensure that the sample size is sufficient to represent the population of interest. To facilitate us in conducting the analysis, in this study, the research articles obtained were grouped based on two sample sizes, namely a sample size smaller than 30 and a sample size greater than or equal to 30. The number and percentage of articles based on sample size are presented in Table 4.

**Table 4. Percentage of Manuscripts by year**

No.	Sample size	Amount	Percentage
1.	Less than 30	7 articles	46.67%
2.	more than or equal to 30	7 articles	46.67%
3.	Others	1 article	6.66%

Based on the articles that have been selected, then analyzed the results of research regarding the effect of giving open-ended problems on students' creative thinking skills. Comprehensively, the research results obtained from the research articles are summarized and presented in table 5.





**Table 5. Summary of Selected Manuscripts**

No.	Author	Result
1.	Sonjaya & Yuliyanto (2022)	“The results showed an increase in students' creative thinking skills by applying an open-ended approach with an n-gain score of 0.69, classified as moderate. Thus, the open-ended approach can influence the creative thinking skills of elementary school students.”
2.	Yuniarti etc. (2017)	“The results of data analysis using statistic of parametric and non parametric showed that: 1) The Achievement mathematical creative thinking ability of students who received open-ended problems based learning analytic-synthetic better than those conventional learning is reviewed whole and each level prior mathematical knowledge as well; 2) the effect size of open-ended problems based analytic-synthetic learning on the achievement of students' mathematical creative thinking ability in high category.”
3.	Fatah etc. (2016)	“The statistics test on the MCTA data show that the MCTA improvement of the students who learn through open-ended approach is better than that of those who learn through conventional way”
4.	Ardiyanti, Suarjana, & Garminah (2013)	"The results of the t-test showed that there were significant differences between groups of students who were taught with an open-ended problem-oriented mathematics learning model, and groups of students who were taught with conventional learning models. The results of the analysis show that the open-ended problem-oriented Mathematics learning model has a positive effect on students' creative thinking skills, compared to conventional learning models."
5.	Dwipayana, & Diputra (2018)	"The results of testing the hypothesis show that the effectiveness size (ES) value is 1.028 which is in high effectiveness ( $0.8 < 1.7$ ), then the f-count is 230.598 more than the t-table value which is 4.03, which is tested at a significance of 5% with $db_{antar} = 1$ and $db_{dalam} = 50$ . This implies that utilizing an open-ended PMRI (Pendidikan Matematika Realistik Indonesia) approach in education is highly effective, leading to distinguishable variations in mathematical creative thinking abilities among students who receive instruction based on the open-ended PMRI approach compared to those who do not.
6.	Agustian, Sujana, & Kurniadi (2015)	“The result from this research proves that learning using the open-ended approach can significantly increase a creative mathematic thinking of student's grade V sekolah dasar. “



7.	Waluyo (2018)	“The results of this study indicate that an open-ended approach can improve elementary school students' thinking skills in mathematics compared to learning mathematics using conventional approaches.”
8.	Ginting (2019)	“The results showed that (1) the improvement of mathematical creative thinking ability and self regulated learning students who received open-ended based brain-gym higher than students who received expository learning. “
9.	Suriyani, Hasratuddin, & Asmin (2015).	“The results of the study show that the improvement of students' creative thinking skills taught using mathematics learning with the Open-Ended approach is better than those taught with conventional learning”
10.	Dwiantara & Masi (2016)	“Based on the results data analysis and discussion obtained the conclusions: (1) The learning process by using the open-ended approach in class XI IPA SMA Negeri 2 Kendari is quite good. Achievement learning during 5 consecutive meetings were 70.59%, 100%, 94.12%, 82.35% and 100%. (2) The average N-Gain mathematical creative thinking ability of students who are taught with the approach open-ended is 0.3639 which is classified as moderate. (3) Average N-Gain creative thinking ability mathematics of students who are taught by conventional learning is 0.3775 which belongs to currently. (4) There is a significant effect of using an open-ended learning approach towards improving students' mathematical creative thinking skills in class XI IPA SMA Negeri 2 Kendari.”
11.	Islam, Budiyono, & Siswanto (2021)	“The results showed that in the aspect of fluency, female students were better than male students in producing ideas, on the flexibility aspect, female students and male students were able to achieve good flexibility aspects by providing varied problem solutions, and in the novelty aspect, female and male students can achieve the novelty aspect by giving different answers”
12.	Wanelly & Fauzan (2020)	"The creative thinking ability of students who are taught with an open-ended approach is better than students who are taught with conventional learning. The creative thinking skills of students with auditory, visual, and kinesthetic learning styles who are taught with an open-ended approach are better than students with auditory, visual and kinesthetic learning styles who are taught with conventional learning. There is no difference in creative thinking skills between auditory, visual and kinesthetic learning styles, and there is no interaction between learning approaches and learning styles in influencing students' creative thinking skills."
13.	Waluyo & Surya (2017)	“Based on the results of research and data analysis, the following conclusions can be drawn: There is an



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	influence of open-ended on the ability to think creatively in mathematics."
14. Agustian etc. (2015)	"The result from this research proves that learning using the open-ended approach can significantly increase a creative mathematic thinking of student's grade V SD."
15. Magelo, Hulukati, Djakaria (2020)	"There are differences in the effect of open-ended learning models and direct learning on learning motivation and mathematical creative thinking skills. From the results of the study, it was found that the open-ended learning model had a more positive effect on students' mathematical creative thinking skills in terms of the level of learning motivation."

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Numerous studies have demonstrated a strong correlation between the introduction of open-ended problems and the enhancement of students' creative thinking abilities. For instance, at the elementary school level, Sonjaya & Yuliyanto (2022) conducted research involving 29 elementary school students to examine the impact of employing an open-ended problem-based approach on students' creative thinking skills. Through quantitative analysis, they obtained an n-gain score of 0.69, which is classified as moderate, thereby highlighting the potential of the open problem approach to enhance students' creative thinking skills. Similarly, Agustian et al. (2015), found that the utilization of the open-ended approach could enhance the creative mathematical thinking of fifth-grade elementary school students. In line with that, Agustian et al. (2015) found the same effect in fifth grade elementary school students. At the junior high school level, giving open-ended problems in learning mathematics also has a positive effect on the results of students' creative thinking skills (Ginting, 2019; Islam, Budiyo, & Siswanto, 2021; Magelo, Hulukati, Djakaria, 2020; Suriyani, Hasratuddin, & Asmin, 2015, Damayanti & Sumardi, 2018). The same results were also obtained in research conducted at the high school level (Fatah et al., 2016; Dwiantara & Masi, 2016). Furthermore, it turns out that the positive influence is not only experienced by students, but also student teacher candidates. Based on research conducted by Yuniarti et al. (2017), The Achievement of mathematical creative thinking ability of students who received open-ended problems based on analytic-synthetic learning is better than those conventional learning that reviewed the whole and each level of prior



mathematical knowledge as well, even it also obtained an effect size in the high category.

Teaching open-ended problems can be effectively facilitated through the implementation of a problem-based learning (PBL) model. The PBL model is an instructional approach that engages students with mathematical problems, requiring them to seek solutions (Boud & Feletti, 1997:15). This pedagogical method provides students with opportunities for exploratory problem-solving and fosters the development of critical thinking skills (Smith & Stock, 2003; Applebee, 2003). Research conducted by Ardiyanti, Suarjana, and Garminah (2013) compared problem-based learning to conventional teaching methods, revealing that the open-ended problem-centered approach to mathematics instruction positively influences students' creative thinking abilities. These findings align with the research conducted by Magelo, Hulukati, and Djakaria (2020), which emphasizes the more pronounced positive impact of open problem-based teaching on students' mathematical creative thinking skills. To avoid monotony in presenting open problems, teachers can enhance engagement by incorporating real-life contexts. One interesting context is the ethnomathematics context. Islam, Budiyo, and Siswanto (2021) conducted research to test whether giving open-ended problems based on ethnomathematics can improve students' creative thinking skills. The results of the study show that giving open-ended problems based on ethnomathematics can help students in terms of fluency, flexibility, and novelty (Islam, Budiyo, & Siswanto, 2021). In addition to ethnomathematics, teachers can use a realistic mathematics approach to teach open-ended problems to students. Dwipayana, and Diputra (2018) found that students who were taught using a realistic mathematics approach based on open-ended problems proved to have higher creative thinking skills than when participating in mathematics learning without a realistic mathematics approach. The results of this study indicate that in providing open-ended problems the teacher can take the initiative in presenting problems, for example with realistic mathematics and ethnomathematics approaches.



## CONCLUSION

Research investigating the impact of presenting open-ended problems on creative thinking skills has garnered significant attention, evident in the substantial volume of studies available. A comprehensive review of the literature reveals that nearly all articles affirm the positive effect of introducing open-ended problems on enhancing students' creative thinking abilities in the context of mathematics education. Furthermore, some articles have demonstrated that the adoption of open problem-based learning methods can further enhance students' creative thinking skills. Hence, it can be deduced that the provision of open-ended problems holds the potential to augment students' creative thinking skills in mathematics learning and that this approach can be cultivated through the utilization of problem-based learning (PBL). Additionally, educators have the option to incorporate realistic mathematics or ethnomathematics approaches when introducing open-ended problems to students.

Although in this study many results have been revealed that support giving open-ended problems to improve creative thinking skills, but they have not been analyzed further regarding the strength and weakness of this influence and the bias between studies. Because of that, suggestions for further research are to conduct further research on how strong the influence of the research results that have been reviewed is. It is necessary to carry out a meta-analysis study to conclude the effect size value of articles on giving open-ended problems to creative thinking skills.

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