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META-ANALYSIS OF CONSTRUCTIVISM'S APPROACHES TO STUDENTS' MATHEMATICAL ABILITY

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ABSTRACT

This study examined the effectiveness of the constructivist approach in enhancing students' mathematical abilities through meta-analysis. Data were gathered from 20 journal publications implementing constructivist teaching strategies in mathematics instruction for Indonesian primary and high school students. Cohen's criteria were applied to assess effect sizes on students' mathematical abilities. The findings indicated that 15 studies (75%) demonstrated small effect sizes (0.0–0.20), suggesting a limited influence on students' mathematical skills. However, all studies showed higher average scores between pretests and posttests, highlighting the potential benefits of the approach. The remaining five studies (25%) reported moderate effect sizes (0.51–1.00), indicating a more substantial positive impact of constructivist methods on students' mathematical aptitude.

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INTRODUCTION

Mathematics is one of the most fundamental sciences in human life, serving as the backbone of knowledge development worldwide. As the foundation of science and technology, mathematics transforms knowledge into an intriguing, structured system characterized by symbols, language, terms, and its relationship to technology and other fields (Acharya, 2017).

Often considered the basis of various disciplines, mathematics plays a critical role in daily life and decision-making. Its capacity to foster problem-solving skills, logical reasoning, and analytical thinking makes it indispensable for students and professionals. In an increasingly data-driven world, mathematical ability is paramount (Chen et al., 2017; Semenets et al., 2022), empowering individuals to navigate complex situations and make informed decisions.

In education, students are introduced to foundational concepts and problem-solving skills in mathematics. However, traditional mathematics education, while long relied upon, is increasingly recognized for its limitations in fostering the critical thinking and problem-solving skills essential in today's complex environment. Constructivism, an educational theory, emphasizes active student involvement in constructing their understanding of the world through experiences and reflection (Ardiansyah & Ujihanti, 2017; Mugambi, 2018; Sharma, 2014). His theory posits that learning is not merely passive information intake but an active process in which individuals build new ideas upon their existing knowledge and experiences.

By engaging with mathematical concepts through constructivist approaches, students gain deeper comprehension and appreciation for the subject, especially as they apply their knowledge in real-world contexts (Cherif et al., 2017; Sidhu & Srinivasan, 2018). Constructivism, with its emphasis on collaboration and communication, not only strengthens students' mathematical skills but also nurtures critical thinking and adaptability (Sari & Musdi, 2020), preparing them for the demands of modern society. This transformative approach not only makes mathematics more relevant but also equips students with essential skills that extend beyond the classroom (Hassi & Laursen, 2015), enabling them to face real-life challenges with confidence and creativity.

Researchers interested in using meta-analysis to study constructivist approaches to enhancing students' mathematical abilities may find this helpful description, as it suggests that constructivist methods can enrich the classroom experience. This area warrants further investigation through meta-analytic research to determine the impact of constructivist approaches on students' mathematical skills. The application of constructivism could positively influence the learning process, improving students' mathematical abilities. To achieve the research objectives, examining the extent to which a constructivist approach affects the mathematical abilities of junior and senior high school students is essential.

METHOD

This study analyzed 20 publications to investigate the impact of the constructivist approach on students' mathematical abilities. The following steps were applied in this meta-analysis:

1. Research Topic Selection: We focused on the effectiveness of the constructivist approach in teaching mathematics.
2. Topic Exploration: The theoretical foundations of constructivism and its applications in math education were explored.
3. Data Collection: Relevant research articles from academic journals examining the use of constructivist methods in mathematics classrooms were collected.
4. Effect Size Calculation and Interpretation: To evaluate the impact of the constructivist approach, we calculated effect sizes based on Cohen's criteria. The interpretation of effect sizes was as follows:

   Table 1. Criteria for Evaluating Effect Size

Size	Interpretation
0.00 - 0.20	Weak Effect
0.21 - 0.50	Modest Effect
0.51 - 1.00	Moderate Effect
> 1.00	Strong Effect

   Table 1 shows that if the calculated effect size is between 0.0 and 0.20, the impact of the constructivist approach on mathematics learning is negligible. Conversely, if the effect size exceeds 1.00, the constructivist approach strongly influences mathematics learning in school.
5. Heterogeneity Analysis: We assessed potential variations in the impact of the constructivist approach across different studies.

RESULT AND DISCUSSION

This meta-analysis included twenty academic articles examining the use of constructivist methods in mathematics instruction, see Table 2. Each study's effect size was quantified and classified according to Cohen's criteria as shown in Table 3.

Table 2. Effect sizes in the application of the constructivist approach.

No	Journal Topic	Analysis Result	Category
1	The Constructivist Approach to Learning Mathematics	$\frac{81{,}05 - 53{,}05}{100} = 0{,}28$	Modest effect
2	Constructivism and Students' Mathematical Problem-Solving Skills	$\frac{75{,}51 - 48{,}73}{100} = 0{,}27$	Modest effect
3	Challenges in Adopting a Constructivist Approach to Learning.	$\frac{74{,}63 - 61{,}75}{100} = 0{,}13$	Weak effect
4	Constructivism and Students' Mathematical Problem-Solving Abilities	$\frac{26{,}51 - 20{,}84}{100} = 0{,}06$	Weak effect
5	Constructivist Learning and Mathematical Reasoning Abilities	$\frac{72{,}50 - 23{,}68}{100} = 0{,}49$	Modest effect
6	The Constructivist Approach to Mathematical Learning Outcomes	$\frac{79{,}50 - 72{,}3}{100} = 0.07$	Weak effect
7	Constructivist Approaches to Mathematical Reasoning and Achievement	$\frac{74{,}95 - 61{,}28}{100} = 0{,}14$	Weak effect
8	The Constructivist Approach to Learning Activities and Achievement	$\frac{88{,}10 - 73{,}8}{100} = 0{,}14$	Weak effect
9	Constructivist Learning Approaches and Academic Achievement	$\frac{73{,}53 - 68{,}44}{100} = 0{,}05$	Weak effect
10	Exploring a Constructivist Approach	$\frac{75{,}56 - 65{,}33}{100} = 0{,}10$	Weak effect
11	The Constructivist Approach to Mathematical Abilities and Conceptual Understanding	$\frac{65{,}42 - 63{,}75}{100} = 0{,}02$	Weak effect
12	The Osborn Model: Enhancing Mathematical Problem-Solving Abilities through Constructivist Theory	$\frac{78{,}174 - 72{,}599}{100} = 0{,}06$	Weak effect
13	Constructivist Learning and Mathematical Problem-Solving Abilities	$\frac{55{,}90 - 36{,}12}{100} = 0{,}19$	Weak effect
14	Realistic Constructivist Applications and Basic Mathematical Skills for Problem-Solving Abilities	$\frac{81{,}926 - 58{,}583}{100} = 0{,}23$	Modest effect
15	Constructivist and Self-Learning Approaches to Students' Mathematical Communication Abilities and Self-Efficacy	$\frac{72{,}55 - 66{,}32}{100} = 0{,}06$	Weak effect
16	The Constructivist Approach and Students' Confidence in Learning Mathematics	$\frac{8{,}56 - 6{,}67}{100} = 0{,}02$	Weak effect
17	The Constructivist Approach to Mathematics Learning Achievement	$\frac{72{,}38 - 65{,}3}{100} = 0{,}07$	Weak effect
18	The Constructivist Approach to Learning Difficulties in Mathematics	$\frac{76{,}63 - 61{,}75}{100} = 0{,}15$	Weak effect
19	A Constructivist Learning Approach to Students' Understanding of Multiplication Concepts	$\frac{62{,}5 - 27{,}5}{100} = 0{,}35$	Modest effect
20	The Needham Model of Constructivist Approach for Enhancing Mathematical Communication Skills	$\frac{82{,}34 - 75{,}37}{100} = 0{,}07$	Weak effect

Table 3. Summary of effects produced

Category	Sum
Modest effect	5
Weak Effect	15

The findings showed that 15 studies, or 75% of the total, were classified as having a weak effect (0.00–0.20). While this suggests a minimal overall impact based on effect size, it is notable that all studies reported an increase in student scores from pre-test to post-test, indicating potential benefits of the constructivist approach despite the statistically weak effect size. The remaining five studies (25%) reported a moderate effect size (0.51–1.00), suggesting constructivism's more substantial positive influence on students' mathematical abilities. If illustrated in a graph, the results would appear as seen in Figure 1.

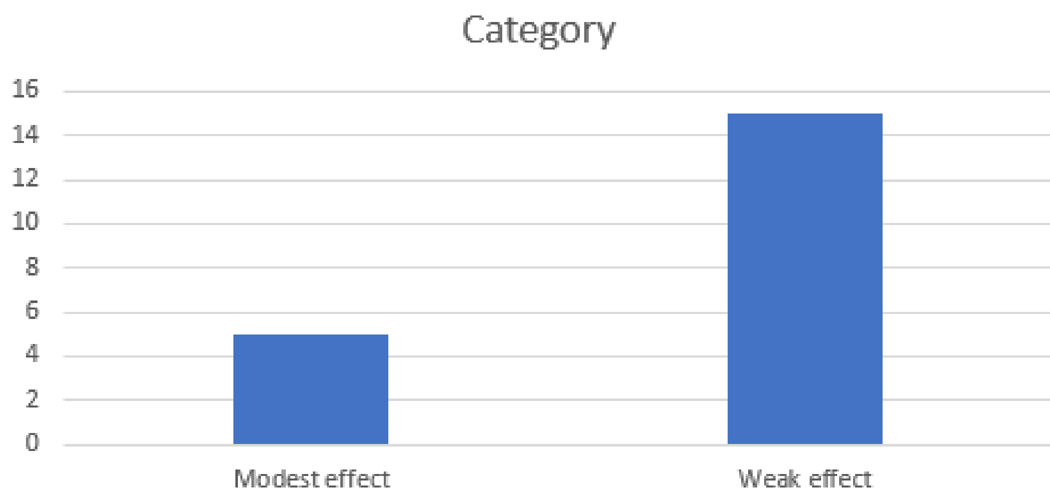

Figure 1. Result of the effect

The constructivist approach is an educational philosophy emphasizing active learning, where students construct their understanding and knowledge of the world through experiences and reflection. This approach encourages collaboration and critical thinking, allowing learners to engage with mathematical concepts meaningfully rather than through rote memorization. Despite its potential benefits, the effectiveness of the constructivist approach often hinges on teacher training and the availability of resources, which can significantly influence how well these principles are put into practice in diverse classroom settings (Mir & Jain, 2016; Zajda, 2018).

Effective implementation also requires a supportive learning environment that fosters exploration and experimentation, enabling students to apply their knowledge in real-world contexts (Hahnraths et al., 2023). The low effect of constructivism's approach to mathematical ability can be attributed to several factors, including the challenges in implementation, the nature of student engagement, and the variability in outcomes across different educational contexts. While some studies indicate positive results, others reveal limited improvements in mathematical skills and metacognitive regulation.

Moreover, constructivism approaches require significant teacher training and curriculum adaptation, which may not always be feasible in all educational settings (Bermejo et al., 2021; Ruchiyat et al., 2024). Inconsistent application of constructivist principles can lead to varied student experiences and outcomes, undermining the effectiveness of the approach (Sharma, 2014). On the other hand, the effectiveness of constructivism approaches often depends on class size, with smaller groups yielding better outcomes (Tamur & Juandi, 2020). Therefore, although the constructivism approach has the potential to improve mathematical abilities, its implementation needs to be carried out more effectively and adjusted to students' needs to provide a more significant impact. Thus, it is important to evaluate and improve the teaching strategies used, as well as provide additional support for teachers and students, so that this approach can be applied more optimally in the mathematics learning process.

CONCLUSION

The findings of this meta-analysis present mixed results. While most studies (75%) showed a weak effect size, all demonstrated increased student scores. This suggests the constructivist approach may offer some potential for improving mathematical abilities, even if its statistical impact is subtle. Additionally, five studies reported a moderate effect size, indicating a more substantial benefit for specific implementations of this approach.

This meta-analysis has limitations. The overall weak effect size may be due to factors such as variations in study design, implementation fidelity, and differences in student populations. Future research could address these limitations by:

1. Conducting more rigorous studies with standardized procedures.
2. Investigating the influence of specific constructivist teaching strategies.
3. Exploring the impact of the approach across diverse

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