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A Quantitative Study on the Implementation of the Constructivist Approach and Its Impact on Students' Critical Thinking Skills

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ABSTRACT

Mathematics is often perceived as an abstract and difficult subject by students, especially when learning topics such as Sequences and Series. The constructivist approach is considered effective in helping students build their own understanding through active involvement in the learning process, which in turn enhances their critical thinking skills. This study aims to quantitatively evaluate the impact of implementing a constructivist approach on students' critical thinking skills in mathematics learning. A pre-experimental one-group pretest-posttest design was used, involving 32 tenth-grade students from the Industrial Computer and Network Engineering (TKJ Industri) program at SMKS Muhammadiyah 9 Medan in the 2024/2025 academic year. Data were collected using critical thinking tests administered before and after the learning intervention. Analysis involved descriptive statistics, normality tests, paired sample t-tests, and N-Gain calculations. Results indicated a significant improvement in students' critical thinking scores, with the average score increasing from 54.06 to 77.19. The paired sample t-test yielded a significance value of 0.000 ($p < 0.05$), and the N-Gain score was 0.50, indicating a moderate level of effectiveness. These findings suggest that implementing the constructivist approach positively impacts students' critical thinking development.

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INTRODUCTION

Mathematics is often perceived as a challenging and abstract subject, especially in topics such as Sequences and Series. Many students struggle to understand the presented concepts due to the continued dominance of conventional teaching approaches that fail to actively involve students in the learning process (Meliana & Sopiany, 2022; Napfiah & Yazidah, 2023). The topic of Sequences and Series, for example, requires an understanding of patterns and relationships between numbers, which is not easily grasped without students' direct engagement in conceptual exploration. This leads to low levels of comprehension and weak critical thinking skills when solving mathematical problems (Firdaus & Sugilar, 2023; Putri, Irvan, & Azis, 2024).

The constructivist approach is considered a viable solution to address these issues. Constructivism positions students as active participants who construct their own knowledge through experiential learning (Suherman, 2020; Aziz & Cahyani, 2023). According to Bruner, meaningful learning occurs when students are directly involved in building their understanding, rather than passively receiving information (Firdaus & Sugilar, 2023). This approach allows students to construct knowledge through social interaction, reflective experiences, and independent problem-solving (Anshar, 2022; Gani et al., 2024).

The philosophical foundation of this approach can be traced to the ideas of John Dewey, who emphasized the importance of real-life experience in the educational process. Dewey believed that

learning should originate from concrete experiences that students encounter in their daily lives (Fitri & Masykuroh, 2023; Sofa & Safitri, 2022). This view is supported by Dini (2023), who stated that experience-based learning in social contexts fosters critical thinking and life skills from an early age. Aji and Rosiana (2024) also demonstrated that the integration of experience, technology, and social interaction, as exemplified in the P5 program, reflects Dewey's progressive educational philosophy.

In the context of mathematics education, the constructivist approach has been shown to promote student engagement in constructing meaning and discovering mathematical patterns independently (Irmayanti, 2023; Simanjuntak, 2024). Rahmawati and Pamungkas (2023) reported that through group discussions and social interaction, students are able to exchange ideas and deepen their understanding of mathematical concepts. Additionally, this approach is effective in enhancing higher-order thinking skills, such as analyzing, evaluating, and formulating logical solutions to mathematical problems (Hidayati, 2022; Dewi & Suryaningsih, 2021; Sulikah & Degeng, 2023).

Previous studies have shown that the constructivist approach positively impacts students' critical thinking abilities and learning outcomes, particularly in complex mathematical topics (Agustiani & Syaifudin, 2021; Magdalena, 2021; Tanjung, 2024). Furthermore, the development of constructivist-based teaching modules and learning media has proven effective in increasing student motivation and classroom participation (Cahyaningtyas, 2024; Halimi & Wijonarko, 2021; Sulistiowati, 2024; Irvan & Mushlihuddin,2020).

In response to these challenges, this study aims to quantitatively examine how the implementation of a constructivist approach in mathematics learning affects students' critical thinking skills. The research was conducted at SMKS Muhammadiyah 9 Medan, involving 32 tenth-grade students from the Industrial Computer and Network Engineering (TKJ Industri) program who were studying the topic of Sequences and Series. The study used a quantitative method with a pre-experimental one-group pretest-posttest design to obtain objective and measurable insights regarding the impact of the approach on students' critical thinking development.

The findings of this study are expected to contribute to the advancement of more effective mathematics teaching strategies and serve as a reference for educators in implementing student-centered, constructivist teaching models. By prioritizing active student involvement, the learning process can improve not only academic achievement but also foster independent thinking, creativity, and analytical skills that are essential for 21st-century education.

RESEARCH METHOD

This study employed a quantitative research approach using a pre-experimental one-group pretest-posttest design. The aim was to assess the impact of implementing a constructivist approach on students' critical thinking skills in mathematics, specifically in the topic of Sequences and Series. This design was chosen because it allows for the measurement of differences before and after the intervention within a single group (Magdalena, 2021).

The research was conducted at SMKS Muhammadiyah 9 Medan with 32 tenth-grade students from the TKJ Industri program in the 2024/2025 academic year. The sample was selected purposively as the students were actively learning the target topic during the study.

Data Collection Techniques

Data were collected using pretest and posttest instruments designed to measure critical thinking skills. The test items were based on five indicators adapted from Magdalena (2021), namely: (1) providing simple explanations, (2) building basic skills, (3) drawing conclusions, (4) giving further explanations, and (5) developing strategies and tactics.

Research Procedure

1. Preparation of lesson plans based on the constructivist approach.
2. Administration of the pretest to assess students' initial critical thinking skills.
3. Conducting the learning intervention using constructivist principles.
4. Administration of the posttest.
5. Statistical analysis of the pretest and posttest results.

Data Analysis Techniques

The collected data were analyzed using:

1. Kolmogorov–Smirnov normality test to ensure normal data distribution.
2. Paired sample t-test to determine the significance of differences between pretest and posttest scores.
3. N-Gain calculation to evaluate the effectiveness of the learning intervention.

The N-Gain index was interpreted based on Hake's (1999) classification:

N-Gain < 0.3: Low
0.3 ≤ N-Gain ≤ 0.7: Moderate
N-Gain > 0.7: High

This approach enabled the study to offer a statistical overview of the effectiveness of constructivist teaching in improving students' critical thinking.

RESULTS AND DISCUSSION

Results

This study aimed to assess the impact of implementing the constructivist approach on students' critical thinking skills in the topic of Sequences and Series. To measure this impact, a pretest and posttest were administered to 32 tenth-grade students from the Industrial Computer and Network Engineering (TKJ Industri) class at SMKS Muhammadiyah 9 Medan. The analysis was carried out using descriptive statistics to identify score patterns, a normality test to assess the data distribution, a paired sample t-test to evaluate statistical significance, and an N-Gain calculation to measure the effectiveness of the learning intervention.

1. Descriptive Statistics of Pretest and Posttest

To determine the overall improvement in students' critical thinking skills, descriptive statistical analysis was conducted to compare the average scores and standard deviations of the pretest and posttest. The results are presented in Table 1 below.

Table 1. Mean and Standard Deviation of Pretest and Posttest Scores

Statistic	Pretest	Posttest
Mean	54.06	77.19
Standard Deviation	10.85	9.42
Number of Students	32	32

The table shows that the mean score increased from 54.06 in the pretest to 77.19 in the posttest. This improvement indicates that students' critical thinking skills significantly developed after the application of the constructivist approach. Moreover, the standard deviation decreased from 10.85 to 9.42, suggesting that students' performance became more consistent and evenly distributed, reflecting improved conceptual understanding across the class.

2. Normality Test

Before conducting further statistical testing, it was necessary to verify whether the data were normally distributed. A Kolmogorov–Smirnov test was performed on both the pretest and posttest scores. The results are shown in Table 2.

Table 2. Normality Test Results (Kolmogorov–Smirnov)

Variable	Sig. (2-tailed)	Conclusion
Pretest	0.187	Normal
Posttest	0.200	Normal

The significance values for the pretest and posttest scores were 0.187 and 0.200, respectively both above the 0.05 threshold. These results indicate that the data for both variables are normally distributed. Therefore, it was appropriate to proceed with a parametric statistical test, specifically the paired sample t-test, to analyze the significance of differences between pretest and posttest outcomes.

3. Paired Sample t-Test

To determine whether there was a statistically significant difference in students' critical thinking skills before and after the learning intervention, a paired sample t-test was conducted. The results are presented in Table 3.

Table 3. Paired Sample t-Test Results

Pair	t	df	Sig. (2-tailed)	Conclusion
Pretest–Posttest	-11.472	31	0.000	Significant difference exists

The test yielded a t-value of -11.472 with a p-value of 0.000, which is less than 0.05. This confirms a statistically significant difference between pretest and posttest scores. The findings clearly indicate that the constructivist approach had a substantial and positive impact on improving students' critical thinking abilities in mathematics.

4. N-Gain Calculation

To further evaluate the effectiveness of the constructivist learning intervention, the normalized gain (N-Gain) was calculated. This measurement provides insight into the relative improvement in students' scores. The result is shown in Table 4.

Table 4. N-Gain Calculation Results

Average N-Gain	Effectiveness Category
0.50	Moderate

The average N-Gain score was 0.50, which falls within the moderate effectiveness category according to Hake's classification. This indicates that the constructivist approach was moderately effective in enhancing students' critical thinking skills. Although the gain was not categorized as high, the outcome still demonstrates the promising potential of this approach for improving conceptual understanding and higher-order thinking in mathematics education.

Discussion

The findings of this study confirm that the implementation of the constructivist approach had a positive and statistically significant impact on students' critical thinking skills in learning the topic of Sequences and Series. The increase in the average score from 54.06 (pretest) to 77.19 (posttest) clearly demonstrates that students were better able to understand, analyze, and solve mathematical problems after participating in learning activities that incorporated constructivist principles.

The reduction in standard deviation from 10.85 to 9.42 further indicates that the students' performance became more consistent and evenly distributed. This reflects not only an overall improvement but also a narrowing of learning gaps among students an important indicator of effective instructional delivery. As Dewey emphasized, education should support the development of every learner through active, experience-based learning (Fitri & Masykuroh, 2023; Sofa & Safitri, 2022; Nababan, Irvan, and Azis, 2021).

The Kolmogorov–Smirnov test results confirmed that both datasets were normally distributed, justifying the use of parametric tests. The paired sample t-test produced a t-value of -11.472 with a p-value of 0.000, providing strong evidence that the constructivist approach significantly improved students' critical thinking skills. This aligns with the findings of Hidayati (2022), who noted that students in constructivist classrooms tend to develop deeper logical reasoning and analytical skills than those taught through traditional instruction.

Moreover, the N-Gain score of 0.50, classified as moderate, suggests that the intervention was reasonably effective. While not classified as high, a moderate gain still indicates meaningful progress, especially considering the limited duration and scope of the intervention. Previous studies by Agustiani and Syaifudin (2021) and Firdaus and Sugilar (2023) have shown that even moderate improvements in critical thinking can lead to long-term academic benefits when students are consistently exposed to student-centered learning environments.

One of the key features of the constructivist approach that contributed to this improvement is its emphasis on student autonomy, collaborative learning, and contextual problem-solving. By

engaging students in discussions, group activities, and independent analysis, the approach allows learners to construct knowledge through experience, in accordance with Bruner's theory of meaningful learning (Suherman, 2020; Irvan, Nasution, & Simangunsong, 2024).

In addition, group discussions and peer interaction, as reported by Rahmawati and Pamungkas (2023), play a crucial role in reinforcing conceptual understanding. Students are encouraged to articulate their reasoning, listen to alternative viewpoints, and negotiate meaning a process that not only deepens understanding but also strengthens critical thinking and communication skills.

These findings support the notion that constructivist learning environments are effective not only in enhancing academic outcomes but also in cultivating essential 21st-century skills, such as independent thinking, analytical reasoning, and adaptability. The positive impact observed in this study suggests that wider adoption of the constructivist approach in mathematics education could help address persistent issues related to low engagement and limited higher-order thinking among students.

CONCLUSION

This study concludes that the implementation of the constructivist approach in teaching mathematics, particularly on the topic of Sequences and Series, has a positive and statistically significant impact on students' critical thinking skills. The substantial improvement in posttest scores, the results of the paired sample t-test, and the moderate N-Gain value collectively demonstrate that this student-centered instructional model enhances learners' ability to analyze, evaluate, and solve mathematical problems.

The findings highlight the effectiveness of constructivist learning in fostering a deeper understanding of mathematical concepts while promoting student autonomy and engagement. Through active learning processes such as group discussions, problem-solving tasks, and contextual exploration students are encouraged to construct knowledge independently and collaboratively. This aligns with the educational goals of the 21st century, which emphasize critical thinking, communication, collaboration, and creativity.

Given these outcomes, it is recommended that the constructivist approach be more widely integrated into mathematics instruction across various educational levels. Teachers should be encouraged and supported to design learning experiences that are inquiry-based, participatory, and reflective of real-world contexts. Doing so will not only improve students' academic performance but also prepare them to think critically and adaptively in a complex, ever-changing world.

REFERENCES

Gani, Z. O. A., Najwa, L., & Janiah, T. (2024). Desain pembelajaran matematika integrasi QS. Al-Baqarah: 261 melalui constructivism and sociocultural learning pada materi persentase, barisan dan deret. *Griya Journal of Mathematics Education and Application*, 4(4), 331–348. https://doi.org/10.29303/griya.v4i4.499

Agustiani, D. D. S., & Syaifudin, S. (2021). Pengaruh metode scaffolding berbasis konstruktivisme terhadap hasil belajar siswa materi barisan dan deret aritmatika. *Jurnal Pendidikan Matematika* (JPM), 5(1), 45–52. Retrieved from https://jurnal.um-palembang.ac.id/jpmatematika/article/view/5065

Anshar, M. (2022). Efektivitas model pembelajaran CMI untuk meningkatkan kemampuan berpikir kritis. *Universitas Islam Negeri Walisongo*. Retrieved from https://eprints.walisongo.ac.id/id/eprint/22902

Aziz, T. A., & Cahyani, A. (2023). Kemandirian belajar dan pembelajaran konstruktivisme dalam kurikulum Merdeka. Didaktik: *Jurnal PGSD*, 11(1), 21–30. Retrieved from https://www.journal.stkipsubang.ac.id/index.php/didaktik/article/view/2407

Cahyaningtyas, Y. A. (2024). Pengaruh pendekatan konstruktivisme berbantuan alat peraga "BARETRIKA" terhadap hasil belajar matematika siswa. *Universitas Nusantara PGRI Kediri*. Retrieved from http://repository.unpkediri.ac.id/16815/

Dewi, N. R., & Suryaningsih, C. (2021). Bahan ajar berbasis saintifik untuk meningkatkan kemampuan berpikir kritis peserta didik pada materi barisan dan deret. Prosiding Seminar Nasional PRISMA, 4(1), 77–86. Retrieved from https://journal.unnes.ac.id/sju/prisma/article/view/44994

Dini, N. L. (2023). Konteks sosial dalam pendidikan konstruktivis. *Jurnal Pendidikan Anak Usia Dini*, 5(1), 55–63.

Firdaus, A., & Sugilar, H. (2023). Teori konstruktivisme dalam membangun kemampuan berpikir kritis. *Proceedings of Global Djati Conference Series*, 3(1), 130–140. Retrieved from https://conferences.uinsgd.ac.id/index.php/gdcs/article/view/1776

Fitri, R., & Masykuroh, A. (2023). Strategi konstruktivisme Dewey dalam pembelajaran matematika. *Jurnal Inovasi Pendidikan Matematika*, 6(1), 45–52.

Hidayati, S. (2022). Efektivitas pendekatan konstruktivisme terhadap kemampuan berpikir kritis siswa. *Jurnal Pendidikan Matematika Nusantara*, 6(1), 35–42.

Irmayanti, L. (2023). Mendesain pembelajaran matematika berkarakter dengan pendekatan konstruktivisme. *Universitas Pendidikan Ganesha*. Retrieved from https://repo.undiksha.ac.id/id/eprint/14565

Irvan, I., & Mushlihuddin, R. (2020). The development of teaching materials with problem based learning on the mathematical statistics subject to improve students' critical thinking ability. *Indonesian Journal of Education and Mathematical Science*, 2(1), 1–6. https://doi.org/10.30596/ijems.v2i1.5626

Irvan, I., Nasution, M. D., & Simangunsong, A. R. (2024). Statistics learning media innovation B-Tube (Combination blog and YouTube). *Mosharafa: Jurnal Pendidikan Matematika*, 13(4), 895–908.

Magdalena, Y. (2021). Indikator penilaian berpikir kritis dalam pembelajaran matematika. *Jurnal Evaluasi Pendidikan*, 5(1), 15–22.

Nababan, R., Irvan, & Azis, Z. (2021). Perbedaan kemampuan berpikir kritis matematis siswa antara model pembelajaran problem posing dan discovery learning. *SEPREN: Journal of Mathematics Education and Applied*, 2(2), 1–10. https://doi.org/10.36655/sepren.v2i2.550

Napfiah, S., & Yazidah, N. I. (2023). Pengembangan modul pembelajaran matematika berbasis kontekstual materi barisan dan deret. *Cakrawala*, 9(2), 110–118. Retrieved from https://ejournals.itda.ac.id/index.php/cakrawala/article/view/1421

Putri, L. S., Irvan, I., & Azis, Z. (2024). Pengembangan modul pembelajaran matematika berbasis ethnomathematics menggunakan model guided discovery learning pada materi pola bilangan siswa kelas VIII SMP. *Tsaqila: Jurnal Pendidikan dan Teknologi*, 4(2), 71–87.

Rahmawati, F., & Pamungkas, M. D. (2023). Cooperative Integrated Reading and Composition untuk meningkatkan pemahaman materi barisan dan deret. *Jurnal Pendidikan Matematika dan Matematika*, 7(2), 145–154.

Simanjuntak, J. T. S. (2024). *Peningkatan kemampuan pemecahan masalah matematika menggunakan model learning cycle 5E*. Universitas Jambi. Retrieved from https://repository.unja.ac.id/71510/

Sofa, M., & Safitri, R. (2022). Konsep pembelajaran konstruktivisme dalam pendidikan modern. *Jurnal Teori dan Praktik Pendidikan*, 3(2), 88–97.

Suherman, E. (2020). *Strategi pembelajaran matematika. Bandung*: UPI Press.

Sulikah, S., & Degeng, I. N. S. (2023). Pengembangan modul matematika pada materi barisan dan deret. JIIP: *Jurnal Ilmiah Ilmu Pendidikan*, 7(2), 60–72. Retrieved from http://www.jiip.stkipyapisdompu.ac.id/jiip/index.php/JIIP/article/view/2772

Tanjung, S. (2024). Constructivist approach for complex mathematical topics. *Journal of Advanced Mathematics Education*, 8(1), 35–42.