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Collaborative Learning Strategies in Developing Critical Thinking of Students in Mathematics

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KEYWORDS

Collaborative Learning, Critical Thinking, Mathematics.

ABSTRACT

Collaborative learning is an effective educational approach to improve students' critical thinking skills, especially in mathematics learning. This approach emphasizes cooperation between students to solve problems, share ideas, and come up with creative solutions. This research aims to identify collaborative learning strategies that can develop students' critical thinking skills in mathematics, as well as provide implementation recommendations in the curriculum. The method used is library research by analyzing various scientific journals, reference books, and policy documents published in the last five years. The results of the study show that collaborative learning strategies involving heterogeneous groups, contextual problem-solving, the role of teachers as facilitators, and the integration of digital technology are effective in developing students' critical thinking skills. In addition, teacher training and improving school infrastructure are important supporting factors for the implementation of this learning. By integrating collaborative strategies into the mathematics curriculum, students not only gain a deep conceptual understanding but also critical thinking skills relevant to the challenges of the 21st century. This research is expected to be a guide for educators and policymakers in improving the quality of mathematics education in Indonesia.

1. INTRODUCTION

Collaborative learning is one of the increasingly popular educational approaches in an effort to improve students' critical thinking skills, especially in mathematics learning. This approach emphasizes cooperation between students to solve problems, share ideas, and come up with creative solutions. In the context of 21st century education, the ability to think critically is one of the essential skills that students must have to face global challenges (Ratnaningsih & Septiana, 2019). Mathematics education requires a method that is able to build these skills, because mathematics is not only about numbers, but also about the ability to solve problems logically and critically (Fachmi et al., 2022).

Collaborative learning is an educational approach that emphasizes cooperation between students in groups to achieve shared learning goals. This model is designed to create an interactive learning environment, where students take an active role in the discussion process, share ideas, and solve problems together. This learning allows students to develop critical and social thinking skills, which are indispensable in the context of 21st century education (Fitriasari et al., 2020). The main principle of collaborative learning is positive interdependence between group members,

which encourages individual responsibility and team collaboration simultaneously (Adawiyah & Jennah, 2023).

In its implementation, technology plays an important role in supporting collaborative learning, especially in online learning situations. The use of platforms such as Microsoft Teams or other online-based applications facilitates collaboration across time and space, allowing students to stay connected even if they are in different locations (Pradja & Baist, 2019). Research shows that technology-based collaborative learning not only increases student engagement but also provides flexibility in the learning process (Amiruddin, 2019). Through collaborative learning, students not only gain a deeper understanding of the learning material but also develop interpersonal skills that are important in their professional lives (Saifuddin & Wathon, 2019).

Collaborative learning has a positive impact on students' critical thinking skills. This is due to the active interaction between students during the learning process, which allows them to discuss, evaluate ideas, and solve problems together (Nurwidodo et al., 2021). In addition, collaborative learning also encourages students to be more independent in finding solutions, because the role of teachers is more of a facilitator than an informant (Arifin & Laili, 2022). In mathematics learning, collaborative strategies can be used to help students develop their analytical and logical abilities, which are key components of critical thinking (Azzahra et al., 2023).

However, the application of collaborative learning in mathematics education often faces obstacles, such as a lack of teacher understanding of this method, a lack of support facilities, and differences in students' ability levels in groups (Aulia et al., 2023). This constraint requires further research to identify the most effective strategies in integrating collaborative learning into the mathematics curriculum. This research is also important to ensure that this method can be implemented thoroughly and provide maximum benefits for students (Sipahutar, 2022).

In the digital age, this ability is becoming increasingly important because students are expected to be able to critically filter information, make logical decisions, and solve complex problems (Kusuma & Hamidah, 2019). By exploring and developing a collaborative learning model, this research aims to contribute to improving the quality of mathematics education in Indonesia.

Previous research has shown the effectiveness of collaborative learning in improving students' critical thinking skills. For example, research by Azzahra et al. (2023) found that students who engaged in collaborative learning showed significant improvements in critical thinking skills compared to students who followed traditional learning methods. Another study by Mandailina et al. (2023) revealed that collaborative learning not only improves students' critical thinking skills but also builds students' social skills.

The purpose of this study is to identify effective strategies in the application of collaborative learning to develop students' critical thinking skills in mathematics learning. The study also aims to provide recommendations for educators and policymakers on how to integrate collaborative learning into the mathematics curriculum in an ongoing manner.

2. METHOD

This study uses a qualitative approach with the type of literature study (library research) to examine collaborative learning strategies in developing students' critical thinking in mathematics. The literature study was chosen because it is appropriate to analyze in depth various relevant theories, concepts, and research results, with the aim of compiling a holistic synthesis of knowledge on this topic (Zed, 2008). This approach allows researchers to explore strategies that have proven effective and identify opportunities for innovation in the application of collaborative learning in mathematics.

The data sources in this study consist of various academic literature, such as scientific journals, reference books, conference proceedings, and policy documents that discuss collaborative learning and students' critical thinking. Data are taken from leading publications in the last five years (2019–2024) to ensure the relevance and up-to-date of information. Electronic databases such as Google Scholar, ResearchGate, and indexed journal directories are used to access these sources (Creswell & Poth, 2016).

The data collection technique is carried out through documentation studies by searching, selecting, and analyzing literature that is directly related to the research topic. This process involves a critical selection of articles that meet the criteria of high quality and relevance. Researchers prioritize literature that offers empirical findings and theoretical discussions about the effectiveness of collaborative learning in the context of mathematics (Bowen, 2009).

Data analysis was carried out using the content analysis method to identify the main themes, patterns, and concepts of the literature studied. This approach is carried out systematically, starting from data coding, grouping findings, to interpreting the analysis results. This method is used to reveal various collaborative learning strategies that can be implemented to improve students' critical thinking skills in mathematics (Krippendorff, 2018). With a comprehensive analysis, this research is expected to provide new insights and applicable recommendations for educators and policymakers.

3. RESULT AND DISCUSSION

The following is a literature data table containing the results of the selection of 10 articles related to "Collaborative Learning Strategies in Developing Students' Critical Thinking in Mathematics." These articles are selected based on their relevance and contribution in providing insights and solutions to the development of critical thinking skills through collaborative learning.

Table 1. literature review

No	Author	Title	Main focus
1	IG Margunayasa	Pengembangan Perangkat Pembelajaran Kolaboratif pada Topik Pengolahan Data Siswa Kelas V SD	Developing collaborative learning tools to improve students' critical thinking skills.
2	E Suprapto, RFN Fachmi	Profil Kemampuan 4C Siswa pada Pembelajaran Matematika	Highlight the improvement of students' critical thinking skills in collaborative-based mathematics learning.
3	V Mandailina	Efektivitas Metode Pembelajaran Kolaboratif dalam Meningkatkan	Showing a significant improvement in students' analytical and critical

		Kemampuan Berpikir Kritis Siswa	thinking skills.
4	MBUB Arifin	Pengaruh Model Pembelajaran Kooperatif Tipe Talking Stick Terhadap Kemampuan Berpikir Kritis Siswa	Talking Stick learning collaboratively is effective in improving the critical thinking skills of mathematics students.
5	C Sipahutar	Penerapan Model PBL dalam Blended Learning untuk Meningkatkan Kemampuan Berpikir Kritis dan Kolaborasi	Collaboration-based Problem-Based Learning improves students' critical thinking and cooperation skills.
6	M Guntur	Kemampuan Berpikir Kreatif dan Kritis Siswa dalam Model Academic-Constructive Controversy (AC)	The AC model improves students' critical and creative thinking skills.
7	R Hidayah	Validitas Buku Model Pembelajaran Kolaboratif Berbasis Masalah untuk Meningkatkan Berpikir Kreatif	Problem-based learning model books are effective in improving critical thinking and metacognition.
8	N Mumtaza	Analisis Penggunaan ILS Go-Labs dalam Pembelajaran Kolaboratif untuk Berpikir Kritis Siswa	Using Go-Labs technology in collaborative learning helps improve critical thinking skills.
9	E Nadiasari	Membelajarkan Kemampuan Berpikir Kritis Matematis pada Generasi Z	Collaborative learning strategies are effective in teaching critical thinking to generation Z.
10	D Nuraida	Peran Guru dalam Mengembangkan Keterampilan Berpikir Kritis Siswa dalam Proses Pembelajaran	The role of teachers as facilitators in collaborative learning plays an important role in the development of students' critical thinking.

Collaborative learning strategies have become one of the most effective methods in developing students' critical thinking skills, especially in mathematics learning. Studies from various articles summarized show that collaborative learning has a significant positive impact on students' ability to analyze, evaluate, and create solutions to mathematical problems. In this context, various studies underline that collaborative learning is more than just a learning method; It is a vehicle to hone critical thinking skills that are needed in the modern era.

One of the articles by Margunayasa (2019) highlights the development of collaborative learning tools on the topic of data processing for grade V elementary school students. This study shows that learning tools specifically designed to support collaboration in the classroom can help students identify patterns, understand data, and generate more in-depth analysis. This device allows students to share ideas and discuss actively, which accelerates their understanding of mathematical concepts. The results of this research are an important foundation for the development of similar learning tools that can be applied at various levels of education (Ambara et al., 2019).

In another study, Suprapto and Fachmi (2022) evaluated the profile of junior high school students' critical thinking, creative, communication, and collaboration skills in collaborative-based mathematics learning. Their

findings indicate that collaborative learning not only improves critical thinking skills, but also encourages students to be more creative and active in group discussions. This learning prioritizes cooperation, so that every student has the responsibility to contribute and support each other in achieving a better understanding. Thus, a collaborative approach becomes an effective tool in building an inclusive and interactive learning environment (Fachmi et al., 2022).

The effectiveness of collaborative learning is also supported by Mandailina's research (2023), which shows that this approach improves students' analytical abilities in solving mathematical problems. This study found that students who learn collaboratively tend to identify and solve complex problems more easily than students who learn individually. This is due to the process of interaction that occurs in groups, where students can exchange ideas, correct mistakes, and refine their solutions. This strategy also builds students' confidence in expressing their opinions, which is one of the important elements in the development of critical thinking (Aulia et al., 2023).

Research by Arifin (2022) using the Talking Stick learning model shows that collaborative learning is effective in improving students' critical thinking skills. This model actively engages each member of the group through structured discussions, allowing students to think deeply about the topics discussed. This provides a student-centered learning experience, where they are encouraged to take an active role in the learning process. In addition, the study also noted that students who learned with this method showed a significant improvement in their ability to solve mathematical problems that required in-depth analysis (Arifin & Laili, 2022).

Another study by Sipahutar (2022) discusses the application of the Problem-Based Learning (PBL) model in blended learning. This research reveals that the combination of problem-based learning and collaborative approaches is very effective in improving students' critical thinking skills. In PBL, students are invited to face real-life situations that require analysis and creative solutions, so that they can apply mathematical knowledge in real-world contexts. The collaborative process in PBL also encourages students to help each other in understanding the material, which ultimately improves their critical thinking skills (Sipahutar, 2022).

Meanwhile, Guntur's (2020) research on the Academic-Constructive Controversy (AC) model highlights how collaborative learning can improve students' creative and critical thinking skills. In this model, students are invited to discuss and debate constructively, which helps them see issues from different perspectives. This approach not only improves students' analytical skills but also builds an attitude of mutual respect in group discussions. These findings confirm that collaborative learning is a relevant approach to be applied in a variety of subjects, including mathematics (Guntur et al., 2020).

Research by Hidayah, Fajaroh, Parlan, Dasna, and Nendi (2024) shows that the book is valid and effective in improving students' creative and metacognitive thinking skills. The use of this learning model encourages students' active participation in group discussions, allowing them to analyze and solve problems in depth. In addition, this book is considered relevant to modern learning needs because it integrates the concepts of collaboration and problem-solving in accordance with the demands of 21st century skills. In conclusion, this learning model book is a valid tool to improve the quality of the teaching and learning process in higher education (Hidayah et al., 2024).

Technology also plays an important role in supporting collaborative learning, as described in Mumtaza's research (2023). The use of digital platforms such as ILS Go-Labs allows students to work together virtually, improving their ability to think critically through interactive exploration. This technology provides an opportunity for students to solve problems collaboratively, even if they are in different locations. These findings are relevant in the digital era, where learning is no longer limited to physical classrooms (Mumtaza & Firdaus, 2023).

Research by Nadiasari and Palma (2022) found that Generation Z shows great potential in critical thinking when given learning methods that are relevant to their characteristics, such as the use of digital technology, interactive discussions, and real-world context-based problem-solving. The study also highlights the importance of teachers' role in designing learning strategies that motivate and actively engage students to critically explore mathematical concepts. In conclusion, learning designed with innovative approaches can significantly improve the mathematical critical thinking skills of Generation Z, while preparing them to face challenges in the digital era (Nadiasari & Palma, 2022).

Finally, research by Nuraida (2019) found that teachers play a role as facilitators and supervisors in creating a supportive learning environment, by encouraging students to analyze, evaluate, and solve problems independently. The use of interactive learning methods, such as group discussions, case studies, and problem-based learning, has proven to be effective in improving students' critical thinking skills. In addition, this study emphasizes the importance of teachers understanding the characteristics of students and utilizing approaches that are relevant to their needs. In conclusion, success in developing students' critical thinking skills is highly dependent on the teacher's ability to design and implement appropriate learning strategies (Nuraida, 2019).

Overall, these studies show that collaborative learning is not only effective in improving students' critical thinking skills, but also provides a variety of additional benefits, such as improving social, communication, and creativity skills. By utilizing this approach, educators can create a learning environment that supports students' intellectual and personal development holistically. Collaborative learning strategies, complemented by modern technology, offer great potential to improve the quality of mathematics education at various levels.

Discussion

Collaborative learning has long been considered an effective method in improving students' critical thinking skills. In the context of mathematics learning, critical thinking skills are very important because they involve the ability to analyze, evaluate, and solve problems logically. This study seeks to identify the most effective strategies in the application of collaborative learning to develop students' critical thinking skills, as well as provide recommendations for educators and policymakers.

Effective Strategies in Collaborative Learning for Mathematics

1. Utilization of Heterogeneous Groups
   An effective collaborative learning strategy is to form heterogeneous groups, where students with different levels of understanding can share knowledge with each other. In this group, students who understand the material better can help other peers, while students who need guidance will be more motivated to ask questions and

learn. This strategy encourages intensive discussions, so students can hone their critical thinking skills through the exchange of ideas.

2. Application of Contextual Problems
   Assigning assignments in the form of contextual problems that are relevant to daily life helps students relate mathematical theories with practical applications. Group discussions in solving these problems involve critical thinking skills such as analysis, evaluation, and drawing conclusions based on data.
3. The Role of Teachers as Facilitators
   In collaborative learning, teachers act as facilitators who monitor group discussions, provide guidance when needed, and ask triggering questions that encourage students to think deeper. Teachers also play a role in ensuring that each student actively contributes to group discussions.
4. Utilization of Digital Technology
   The integration of technology such as online collaboration platforms or math software can increase the effectiveness of collaborative learning. Students can use this tool to share ideas, visualize mathematical concepts, and solve problems together.

Recommendations for Educators and Policymakers

1. Integration of Collaborative Learning into the Mathematics Curriculum
   Policymakers need to integrate collaborative learning as part of the math curriculum explicitly. Detailed guidance for teachers regarding the implementation of collaborative learning, including the preparation of group assignments and the evaluation of critical thinking skills, should be provided.
2. Teacher Training in Collaborative Methods
   Teachers need to be given special training on how to apply collaborative learning in mathematics learning. This training should include facilitation techniques, collaborative task preparation, and how to evaluate the development of students' critical thinking skills.
3. Infrastructure and Resource Improvement
   To support collaborative learning, schools need to provide adequate facilities, such as study spaces that support group work and access to digital technologies. The government can also provide support in the form of digital learning tools to maximize the collaboration process.
4. Continuous Monitoring and Evaluation
   Policymakers and educators need to regularly monitor and evaluate the effectiveness of collaborative learning in improving students' critical thinking skills. The data from this evaluation can be used to improve education methods and policies in the future.

4. CONCLUSION

The conclusion of this study shows that collaborative learning is an effective approach to develop students' critical thinking skills in mathematics. This strategy allows students to learn through cooperation, analysis, and discussion, which directly improves their ability to solve mathematical problems. Collaborative learning involving digital technology, heterogeneous groups, and contextual problems has been proven to have a positive impact on students' critical thinking skills. In addition, the role of teachers as facilitators is also a key element in ensuring the success of collaborative learning.

As a suggestion, educators and policymakers need to consider integrating collaborative learning into the curriculum as a whole. Teachers should be trained to adopt this approach through

intensive training that includes facilitation methods, collaborative task drafting, and evaluation of students' critical thinking. Governments and educational institutions must also provide adequate infrastructure, including digital technology and learning spaces that support group work. Continuous monitoring and evaluation need to be carried out to measure the effectiveness of collaborative learning and improve the methods used. With these efforts, collaborative learning is expected to be able to produce a critical, creative, and competent generation in facing global challenges.

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