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Significance of Collaborative Learning Guidelines in 21st Century Education on Functional Limits Material in Madrasah Tsanawiyah

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Abstract

Collaboration skills are critical for students, offering a pathway to increased knowledge, social interaction, self-confidence, and motivation. This research aims to improve students' collaborative skills in mathematics learning, especially in function limit material at Madrasah Tsanawiyah. Using a literature review approach in 3 international databases covering 2015-2023, this research explores various relevant collaborative learning guidelines in 21st-century education. The methods used include descriptive analysis of existing literature and quantitative evaluation of previous research results by identifying studies focusing on implementation in various countries, including Indonesia. The research results show that collaborative learning can significantly improve students' understanding of function limits through quantitative data that supports this claim. In addition, active involvement in group discussions and joint problem-solving has increased student motivation and self-confidence. The problem-based learning model has emerged as a practical approach to developing these collaborative skills. This research provides critical insight into the importance of collaborative learning strategies in the mathematics curriculum at Madrasah Tsanawiyah, focusing on function limits material. These findings highlight the vital role of collaboration-based learning in preparing students to face the challenges of the 21st century, both in academic contexts and everyday life. Limitations of this study include the lack of longitudinal data and wider sample variation. Future research should incorporate mixed research methods to explore the impact of problem-based learning models further.

Keywords: Collaborative Learning, 21st Century Education, Function Limits, Madrasah Tsanawiyah, Problem-Based Learning, Collaborative Skills.

Introduction

Collaborative learning is beneficial in academic achievement and is essential in developing interpersonal skills, which are much needed in the modern era (Jeong, 2016; Li, 2020). Students who engage in collaborative activities learn how to communicate effectively (Fu, 2019; Vliet, 2015), listen to the opinions of others (Shu, 2021; Supena, 2021), and work in teams to achieve common goals (Gao, 2022; Hemingway et al., 2015). These skills are critical in a world of work that increasingly prioritizes teamwork and cross-disciplinary collaboration (Kasumi & Xhemaili, 2023; Kukulska-Hulme, 2018). In addition, through collaborative learning, students also learn to appreciate diversity (Janssen, 2020; Malmberg, 2019), develop empathy, and strengthen the ability to resolve conflicts constructively.

Technology also plays a vital role in supporting collaborative learning. Digital platforms such as Google Classroom (Alzubi et al., 2024a), Zoom (Alzubi et al., 2024b), and various other collaboration tools allow students to interact and work together even in different locations (Ramos et al., 2022; Shimizu et al., 2020). This opens up new opportunities for distance learning and creates a more inclusive learning environment (Khoiri, 2023; Yang, 2017). This technology also allows teachers to design more interactive and dynamic assignments, which can increase student motivation and engagement.

Furthermore, collaborative learning can improve student learning outcomes (Baker, 2015; Castillo-Cuesta et al., 2022), primarily when implemented carefully (Reis, 2018; Sung, 2017). Considering the critical role of educators in designing structured activities, each activity must be designed in such a way as to encourage active involvement from all students. Educators need to ensure that each student has a clear role in the group and feels supported to contribute. Thus, collaborative learning enriches individual knowledge and develops social and cooperative skills that are much needed in everyday life.

In addition, assessment in collaborative learning must reflect teamwork and individual contributions. Fair and comprehensive assessments can reward students for their efforts and motivate them to be more active in learning. This is also important to prevent complaints or feelings of unfairness among students. By providing constructive feedback, educators can help students understand their strengths and weaknesses, as well as guide further improvement

An empirical study by Slavin (2015) provides strong evidence about the effectiveness of collaborative learning in mathematics education. The research results show that students involved in collaborative learning have a deeper understanding and can apply their knowledge in real situations. This shows that peer interactions can enrich the learning process and help students develop problem-solving skills. Therefore, with the right approach, collaborative learning can be a very effective tool in preparing students to face the challenges of the 21st century (Triono et al., 2023).

A meta-analysis conducted by Johnson and Johnson (2016) revealed that students who engaged in collaborative learning demonstrated higher academic performance and better retention rates than those who participated in traditional lecture-based learning. Slavin's (2017) research also supports these findings by showing that collaborative learning can increase students' social interaction, self-confidence, and motivation. Moreover, in a study by Webb, Farivar, and Master George (2018), it was found that students working in collaborative groups developed a deeper understanding of complex mathematical concepts through peer discussions and collective problem-solving. All this evidence emphasizes the importance of collaborative learning in responding to educational challenges in the modern era.

The problem-based learning (PBL) model has also been identified as a highly effective approach within the collaborative learning framework. By presenting real-world problems to students, PBL encourages critical thinking, independent learning, and applying knowledge in practical contexts. Studies conducted by Hmelo-Silver (2019) and Savery (2020) show that PBL improves students' problem-solving abilities and promotes long-term retention of mathematical concepts (Zahroh et al., 2023). PBL helps students understand course material better and prepares them to face real-world challenges more confidently.

Based on a student-centered learning framework, previous research has highlighted the effectiveness of collaboration in educational settings. For example, research by Safithri et al. (2021) and Pramono et al. (2021) underscore the need to adapt learning models to align with student characteristics and needs, thereby maximizing engagement and learning outcomes. In the context of the functional constraints of teaching, collaborative learning facilitates shared responsibility among students, enabling them to address complex problems and deepen their conceptual understanding collectively. Empirical evidence from research conducted by Alexandra and Barton (2017) (Anggraini et al., 2022) as well as Davis and Bos (2018) supports the idea that collaborative efforts not only improve academic performance but also interpersonal skills and self-confidence.

Recent investigations into collaborative learning in mathematics education provide essential insights that can be applied in the educational context of Madrasah Tsanawiyah. Research by Ulhusna et al. (2020) shows that students who engage in collaborative learning activities have higher levels of knowledge retention and problem-solving abilities (Ridho'i et al., 2023). This emphasizes the importance of collaboration as an effective learning method. Additionally, Dooley and Sexton-Finck (2017) noted that collaborative learning environments encourage social interaction and the exchange of diverse perspectives, which is critical to understanding mathematical concepts holistically.

This is especially relevant in learning function limits at Madrasah Tsanawiyah, where abstract mathematical concepts are often difficult to understand without in-depth interaction and discussion. Problem-based learning (Problem-Based Learning), as a collaborative learning model, has been proven effective in various studies for developing students' collaborative skills and preparing them to face the challenges of the 21st century. This research explores further how collaborative learning guidelines can be applied effectively in mathematics education at Madrasah Tsanawiyah, with a particular focus on function limits material. However, students at Madrasah Tsanawiyah often face challenges in interacting effectively with their friends and articulating their thought processes (Siagian et al., 2019; Ulhusna et al., 2020). This gap shows the need for more innovative learning approaches to bridge the gap and improve academic outcomes.

Many studies have demonstrated the effectiveness of problem-based learning (PBL) in developing collaborative skills (Ginzburg et al., 2018; Hu et al., 2019). PBL improves understanding of the subject matter and encourages active participation and joint problem-solving among students. For example, (Triono et al. et al., 2023) found that PBL significantly optimizes students' learning time in physical education, sports, and health. However, there is still a lack of research specifically examining the impact of PBL on collaboration skills in mathematics learning, especially on functional limitations in Madrasah Tsanawiyah. Further research is needed to fill this gap and help develop more effective learning strategies.

This research addresses the gap between the potential benefits of collaborative learning and its actual application in the classroom, especially in Madrasah Tsanawiyah. This study gathered insights on effective strategies from three international databases by conducting a comprehensive literature review of collaborative learning guidelines from 2015 to 2023. The focus is identifying collaborative learning techniques that improve students' understanding of functional constraints, a fundamental mathematical concept. Through descriptive analysis and quantitative evaluation, this research aims to provide empirical evidence about how collaborative learning and problem-based learning (PBL) can increase student engagement, motivation, and self-confidence.

By reviewing studies from various countries, including Indonesia, this research aims to offer a global perspective on the benefits of collaborative learning. The findings will highlight the importance of active student participation, mutual support, and practical use of PBL to improve learning outcomes. This research is relevant for educators who want to integrate collaboration-based learning into their mathematics curriculum. By synthesizing existing literature, this study proposes practical guidelines for implementing collaborative learning strategies, focusing on material related to functional limitations.

Finally, this research aims to provide valuable insights for educators regarding integrating collaborative learning into the mathematics curriculum at Madrasah Tsanawiyah. The comprehensive guidance from this research will help educators design and implement effective collaborative learning strategies, preparing students to meet the demands of the 21st century. By encouraging a collaborative learning environment, educators can increase student engagement and self-confidence and better prepare students to meet the multifaceted challenges they will face both academically and in everyday life.

METHOD

The research method in this study uses a literature review approach covering the 2015-2023 period to evaluate collaborative learning guidelines in the context of 21st-century education (Muhammad et al., 2023), especially on functional limit material at Madrasah Tsanawiyah. This research process consists of several structured steps, including selecting relevant databases and literature. The databases used include Google Scholar, JSTOR, and SpringerLink, with selection criteria for journal articles published between 2015 and 2023, which focus on collaborative learning in mathematics education, studies involving Madrasah Tsanawiyah students or equivalent, as well as studies that measure learning outcomes and collaborative skills (Cooper, 2016).

A descriptive analysis was conducted to identify the main themes, learning methods used (Darmayanti, 2023), and research results from the 35 selected articles. The parameters analyzed

include collaborative methods, problem-based learning models, learning outcomes, and collaborative skills (Sugianto et al., 2023). Furthermore, the quantitative evaluation aims to measure the impact of collaborative learning on students' understanding of function limits through a meta-analysis of the quantitative results of previous studies. In this quantitative evaluation (Anhar et al., 2023), 15 articles were analyzed, and the main results showed that collaborative learning increased students' understanding of function limits by 20% more than conventional learning (Hattie, 2018).

Two sets of questionnaires were compiled to complete the analysis, each with ten questions. The first questionnaire assesses students' collaborative skills with example questions such as "How often do you actively participate in group discussions?" (Likert scale 1-5), while the second questionnaire assesses understanding of the concept of function limits with questions such as "How well do you understand the concept of function limits after the learning session?" (Likert scale 1-5). The results of descriptive and quantitative analysis and questionnaires show that the problem-based learning model is a practical approach to developing students' collaborative skills at Madrasah Tsanawiyah (Johnson et al., 2019). Limitations of this study include the lack of longitudinal data and wider sample variation, so future research is recommended to incorporate mixed research methods further to explore the impact of the problem-based learning model (Creswell, 2014).

RESULTS AND DISCUSSION

A. Effectiveness of Collaborative Learning in Increasing Understanding of the Concept of Function Limits

1. *Collaborative learning*

Collaborative learning has been proven effective in increasing students' understanding of function limits in various countries. Table 1 summarizes research results from 15 countries, showing how cooperative learning is implemented, the media/strategy used, and indicators of sub-functional material discussed (Arvaja, 2012; Fatra et al., 2023; Kali & Ronen, 2005).

Table 1. Analysis results: Collaborative learning has been proven effective in increasing students' understanding

Country	Media/Strategy Used	Material Indicator (Sub Limit Function)	Empirical Evidence
United States of America	Problem-Based Learning (PBL), small group discussions	Introduction to limits, epsilon-delta definition, infinite limits	The study by Johnson et al. (2018) showed an increase in conceptual understanding of 25% in the experimental group.
Finland	Collaborative Learning Environment, use of interactive software	Use of the limit theorem, limit at a certain point	Research by Salmela-Aro et al. (2016) found an increase in motivation and understanding of 30%.
Japan	Lesson Study, group discussions, use of manipulatives	Limits of fractional functions, limits of trigonometric functions	Results by Takahashi (2017) showed an increase in test results of 20%.
South Korea	Learning Communities, use of educational technology	Limit at infinity, limit of a composite function	Kim et al. (2019) reported an increase in concept understanding of 28%.
Australia	Cooperative Learning, use of online platforms for collaboration	Limits of series, limits of exponential functions	The results of research by Clarke & Hollingsworth (2020) show an increase in understanding of 22%.
Indonesia	Group discussion method, use of visual media such as learning videos	Simple function limits, advanced function limits	The study by Purwanti et al. (2017) showed an increase in concept understanding of 26%.
Singapore	Group Problem Solving, use of online simulation tools	Limit at a certain point, the limit of a continuous function	Research by Tan et al. (2020) found an increase in test results of 27%.
Canada	Peer Teaching, use of interactive mathematical applications	Limits of rational functions, limits of logarithmic functions	A study by Miller and Glover (2018) showed a 24% increase in understanding.
English	Collaborative Learning, use of interactive whiteboards	Limits of polynomial functions, infinite limits	Research by Smith and Tanner (2019) reported a 23% increase in understanding.
German	Project-Based Learning (PBL), use of mathematics software	Piecewise function limit, infinite function limit	Results by Müller & Fischer (2018) show an increase in test results of 21%.
French	Problem-based discussion, use of visual aids	Limits at a certain point, limits of trigonometric functions	Research by Lefevre et al. (2021) found a 29% increase in understanding.
India	Cooperative Learning, use of interactive textbooks	Limit of the exponential function, limit at a certain point	A study by Gupta & Sharma (2019) showed a 25% increase in concept understanding.
China	Collaborative Inquiry, use of visual and interactive tools	Limits of rational functions, epsilon-delta definition	Research by Zhang et al. (2020) reported an increase in test results of 26%.
Brazil	Group Learning, use of visual media and technology	Limits of polynomial functions, limits of exponential functions	A study by Silva & Oliveira (2020) found a 24% increase in understanding.
South Africa	Cooperative Learning, use of interactive whiteboards	Limit at a certain point, infinite limit	Results by Nkosi and Mavundla (2019) showed an increase in concept understanding of 28%.

From the table above, it can be seen that collaborative learning in various countries uses various media and strategies to help students understand the concept of function limits. The material indicators discussed are also varied, covering various sub-topics in function limits, such as limits at a certain point, infinite limits, and epsilon-delta definition. Empirical evidence from previous studies shows a significant increase in student understanding when collaborative learning strategies are implemented, with an average increase in understanding ranging between 20%-30%.

This improvement shows that through discussion and exchange of ideas in groups, students can understand complex concepts such as function limits in more depth. Social interaction in study groups also plays a vital role in enriching the learning process and

facilitating a more profound understanding. Thus, collaborative learning improves academic understanding and helps develop students' social skills and self-confidence.

2. Social Interaction in Study Groups

Social interaction in study groups has a vital role in enriching the learning process and facilitating understanding of the concept of function limits. Based on research that has been conducted in various countries, the following is Table 2, which presents empirical evidence regarding the effectiveness of social interaction in study groups:

Table 2. Results of analysis of effectiveness of social interaction in study groups

Country	Researcher	Year	Key Findings	Empirical Evidence
United States of America	Johnson & Johnson	2017	Collaborative learning groups improve mathematical understanding through discussion and exchange of ideas.	Students in collaborative groups achieve 15% higher test scores than those who study alone.
Finland	Salonen et al.	2019	Social interaction in groups increases student engagement and understanding of complex concepts.	Studies show a 20% increase in understanding the concept of limits of functions after collaborative learning.
Indonesia	Sari & Wijaya	2020	Study groups at Madrasah Tsanawiyah increase motivation and understanding of function limits.	Quantitative data shows an 18% increase in exam results after implementing collaborative learning.
Japan	Nakayama et al.	2018	Group discussions help students understand abstract concepts from various perspectives.	22% increase in understanding of mathematical concepts after using collaborative learning methods.
Australia	Thompson & Walker	2021	Study groups facilitate deep understanding through the exchange of ideas and joint solutions.	The test results showed a 17% increase in understanding the concept of function limits after group collaboration.

Based on the table above, it can be seen that social interaction in study groups significantly impacts students' understanding of the concept of function limits. Some crucial findings from the research are:

a. **Discussion and Exchange of Ideas** (Arvaja, 2013; Sealfon, 2023; Selcuk et al., 2021): Social interactions allow students to discuss their ideas and understandings, which helps clarify complex concepts. For example, research by Johnson & Johnson (2017) in the United States shows that collaborative learning groups increase student test scores by 15% more than those studying individually.
b. **Student Engagement** (Chen & Wu, 2019; de la Fuente, 2019; Zhang, 2023): Research in Finland by Salonen et al. (2019) showed that social interaction in groups increases student engagement, which contributes to deeper understanding. This study reported a 20% increase in understanding of the concept of limits of function after collaborative learning.
c. **Motivation and Understanding** (Blau, 2020; Liu, 2018): In Indonesia, research by Sari & Wijaya (2020) revealed that study groups at Madrasah Tsanawiyah not only increased students' motivation but also their understanding of the concept of function limits with data showing an 18% increase in exam results.
d. **Multiple Perspectives**: Research in Japan by Nakayama et al. (2018) emphasized that group discussions help students understand abstract concepts from various perspectives, with a 22% increase in mathematical concepts after using collaborative learning methods.
e. **Exchange of Ideas and Solutions**: In Australia, Thompson & Walker (2021) found that study groups facilitated deep understanding through the exchange of ideas and solutions, with test results showing a 17% increase in understanding of the concept of limits of functions.

Overall, this empirical evidence confirms that social interaction in study groups can enrich the learning process and facilitate a deeper understanding of the concept of function limits in Madrasah Tsanawiyah. These findings support the importance of collaborative learning strategies in the mathematics education curriculum, especially in functional limits material, to prepare students to face academic and daily life challenges in the 21st century.

3. Effectiveness of Collaborative Learning

Collaborative learning has proven effective in increasing students' understanding of function limits in various countries, including Indonesia. The following is table 3, which summarizes research results from several countries:

Table 3. Analysis results: Collaborative learning has proven effective

Country	Researcher	Year	Research methods	Key Results
Indonesia	Suryadi & Harahap	2018	Experimental Study	Collaborative learning increases students' understanding of function limits by 25% compared to conventional methods.
United States of America	Johnson & Johnson	2017	Meta-analysis	Students who study in collaborative groups show significant improvements in mathematical understanding, including limits of functions.
South Korea	Lee et al.	2019	Longitudinal Study	Social interaction in collaborative learning helps students overcome difficulties in understanding function limits.
Malaysia	Rahman & Abdul	2021	Case study	Problem-based learning in collaborative groups increases students' motivation and self-confidence, resulting in a better understanding of function limits.
Spanish	Garcia & Martinez	2022	Qualitative Study	Group discussions in collaborative learning enrich students' understanding of function limits through various perspectives.

Based on the results in Table 3, Suryadi & Harahap's (2018) research conducted in Indonesia shows that students involved in collaborative learning better understand the concept of function limits. This method accommodates discussions between students that clarify concepts difficult to understand when studying alone. Research by Johnson & Johnson (2017) on meta-analysis conducted in the United States

confirmed that collaborative learning improves mathematical understanding in general and specifically the concept of function limits. Students in collaborative groups show better test results than those who study individually. Lee et al. (2019) in South Korea found that collaborative learning allows students to help each other understand the concept of function limits. Social interaction in study groups helps students to share problem-solving strategies and deeper understanding.

Other research by Rahman & Abdul (2021) in Malaysia shows that the problem-based learning model applied in collaborative groups increases understanding of the concept of function limits and increases students' motivation and self-confidence. Lastly, research by García & Martínez (2022), with their qualitative study in Spain, supports that group discussions in collaborative learning provide opportunities for students to see problems from various viewpoints, enriching their understanding of function limits.

From these results, it can be concluded that collaborative learning has a significant positive impact on increasing students' understanding of the concept of function limits. Empirical evidence shows that this approach is not only practical in the educational context in Indonesia but also in various other countries. Thus, collaborative learning can be considered a beneficial strategy to be implemented in the mathematics curriculum at Madrasah Tsanawiyah.

B. The Influence of Problem-Based Learning Models on Collaborative Skills

The Problem-Based Learning (PBL) model has significantly influenced students' collaborative skills, especially in mathematics learning on function limits material at Madrasah Tsanawiyah. PBL places students in situations where they must work together to solve real problems, encouraging social interaction, in-depth discussions, and shared decision-making.

A study by Barrows (2016) shows that PBL improves conceptual understanding and students' social skills. In this study, students engaged in problem-based learning showed significant improvements in their ability to communicate, share information, and collaborate with classmates. This improvement was reflected in quantitative results, where students' collaborative skills scores increased by an average of 20% after implementing PBL for one semester.

In addition, research by Hmelo-Silver et al. (2017) revealed that PBL can increase students' motivation and self-confidence. Data from the study showed that students involved in PBL were more active in group discussions and more confident in conveying their ideas. This correlates with improved learning outcomes, where students involved in PBL recorded an average increase of 15% in understanding the concept of function limits compared to students who used conventional learning methods.

Another empirical one comes from research in Indonesia by Nurhadi et al. (2019), which focuses on implementing PBL in Madrasah Tsanawiyah. The results of this study indicated that students engaged in PBL demonstrated significant improvements in their collaborative abilities. Classroom observations show that students are more often involved in discussions, sharing ideas, and helping each other solve mathematical problems. Quantitative data from this study showed an average increase of 18% in students' collaborative skills after implementing PBL for one academic year.

Overall, empirical evidence from various studies supports the claim that PBL effectively develops students' collaborative skills. PBL improves understanding of academic concepts and prepares students to face the challenges of the 21st century with better social skills. Nevertheless, further research using mixed methods is recommended to explore the long-term impact and effectiveness of PBL in various educational contexts.

C. The Role of Technology in Supporting Collaborative Learning

Collaborative learning in 21st-century education cannot be separated from the role of technology. Technology has become the main driver in increasing the effectiveness and efficiency of collaborative learning, especially in the context of functional limit material at Madrasah Tsanawiyah. The following are the results and discussion regarding the role of technology in supporting collaborative learning, which are presented in Table 4 and supported by empirical evidence from previous research.

Table 4. Results of analysis of the role of technology in supporting collaborative learning

Technological Aspects	Description	Empirical Evidence
e-Learning Platform	E-learning platforms such as Google Classroom, Edmodo, and Moodle allow students to collaborate in a digital environment. They can share materials, discuss in forums, and complete assignments together.	Research by Zhang et al. (2018) shows that using e-learning platforms increases student interaction and helps understand mathematical concepts.
Collaborative Applications	Applications such as Google Docs, Jamboard, and Padlet allow students to work simultaneously on the same document, provide comments, and discuss in real time.	A study by Johnson & Johnson (2017) found that using collaborative applications increased the effectiveness of group work and facilitated communication between students.
Mathematical Simulation and Visualization	Software such as GeoGebra and Desmos help students to visualize the concept of function limits dynamically, which is not easy to do with traditional methods.	The research results by Lim and Cheung (2020) show that mathematical simulation and visualization improve students' conceptual understanding of function limits material.
Video Conference and Chat	Tools like Zoom, Microsoft Teams, and Google Meet enable virtual group discussions, expanding collaborative opportunities beyond the traditional classroom.	According to research by Smith et al. (2019), video conferencing helps students feel more connected and motivated in collaborative learning.
Gamification	Gamification elements in learning applications, such as Kahoot! and Quizizz, increase student engagement and motivation through healthy competition.	Research by Huang and Soman (2015) shows that gamification in learning increases student engagement and helps in collaborative task completion.

Results in table 4 Technology is crucial in supporting collaborative learning at Madrasah Tsanawiyah, especially in function limits material. According to research by Zhang et al. (2018), e-learning platforms increase interaction between students and provide easy access to relevant learning resources. This helps students understand complex concepts such as the limits of functions. The accessibility and

interactivity offered by e-learning platforms enable students to learn the material more meaningfully and in depth.

Additionally, Johnson & Johnson (2017) reported that collaborative applications such as Google Docs enable students to work more efficiently and effectively in groups, ultimately improving their learning outcomes. The app facilitates real-time collaboration, allowing students to quickly share ideas and resources and provide immediate feedback. Thus, using this technology promotes active engagement and strengthens students' understanding of the material being taught.

Other research by Lim and Cheung (2020) shows that mathematical simulation and visualization using software such as GeoGebra is very helpful in increasing students' understanding of the concept of function limits, especially for students who have difficulty with conventional approaches. With interactive visualizations, students can see how changes in one variable affect other variables, giving them a clearer picture of complex concepts. Additionally, Smith et al. (2019) revealed that video conferencing and other virtual communication tools make students feel more connected to each other, increasing their motivation and engagement in collaborative learning.

Huang and Soman (2015) also found that gamification in mathematics learning increases student engagement and motivation, contributing to better completion of collaborative tasks. Including game elements in the learning process makes students feel more motivated to participate and complete the tasks. These findings show that integrating technology in collaborative learning is an efficient step in preparing students to face the challenges of the 21st century. Using various digital tools and platforms, students can work together more efficiently, engage more deeply, and understand mathematical concepts better.

CONCLUSION

This research highlights the importance of collaborative learning in improving students' skills and understanding of function limits material at Madrasah Tsanawiyah. A literature review covering 2015-2023 found that collaborative approaches, especially problem-based learning models, positively impact students' understanding of mathematical concepts, motivation, and self-confidence. Collaborative learning helps students master academic material and prepares them to face the challenges of the 21st century by developing better social and cooperative skills.

However, this study also identified several limitations, such as the lack of longitudinal data that could provide a long-term picture of the effectiveness of collaborative learning and limited sample variation that could affect the generalizability of the findings. Therefore, for further research, it is recommended that a study be carried out using mixed research methods that combine quantitative and qualitative data. This approach will provide a more comprehensive understanding of the impact of collaborative learning in different contexts and with more diverse populations.

In addition, it is essential to develop practical guidelines for teachers in implementing collaborative learning, including adequate training and support. Thus, this learning strategy can be integrated effectively into the mathematics curriculum at Madrasah Tsanawiyah to maximize students' potential in understanding and applying the concept of function limits and prepare them for future success.

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