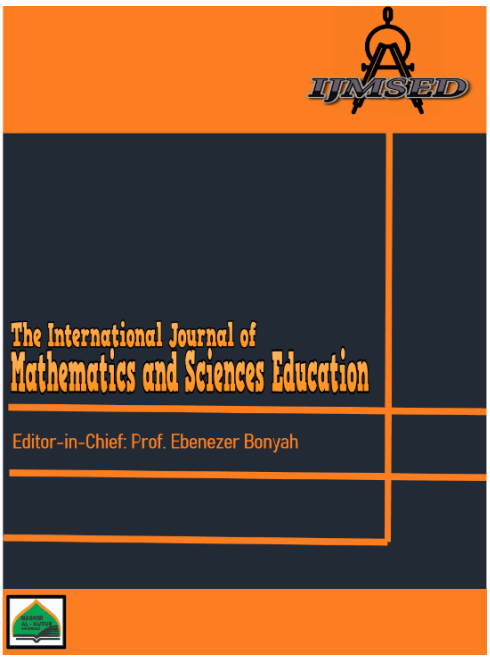
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Aprianah Puspa Sari Dewi[a*], Ema Linda Wahyuni[b], Moh. Rizal[c], Muhamad Galang Isnawan[d], Imam Fakhrurrozi[e]

[a]Departement of Mathematics Education, Universitas Nahdlatul Wathan Mataram, aprianahpuspa227@gmail.com
[b]Departement of Mathematics Education, Universitas Nahdlatul Wathan Mataram, lindawahyuni1006@gmail.com
[c]Departement of Mathematics Education, Universitas Nahdlatul Wathan Mataram, muhammadrizaltuga@gmail.com
[d]Departement of Mathematics Education, Universitas Nahdlatul Wathan Mataram, galangisna19@gmail.com
[e]Departement of Mathematics Education, Universitas Nahdlatul Wathan Mataram, imamfahri123@gmail.com

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[b]Departement of Mathematics Education, Universitas Nahdlatul Wathan Mataram, lindawahyuni1006@gmail.com
[c]Departement of Mathematics Education, Universitas Nahdlatul Wathan Mataram, muhammadrizaltuga@gmail.com
[d]Departement of Mathematics Education, Universitas Nahdlatul Wathan Mataram, galangisna19@gmail.com
[e]Departement of Mathematics Education, Universitas Nahdlatul Wathan Mataram, imamfahri123@gmail.com

*Corresponding Author: aprianahpuspa227@gmail.com

Abstract
Telegram has significant potential as a virtual teaching tool in mathematics education due to its various advantages over other applications. This study aims to identify, review, and evaluate relevant research on the use of Telegram in mathematics learning, using the Systematic Literature Review (SLR) method. The process involves several stages: a) problem formulation, where the researchers define the problem to be explored in depth based on the selected topic, and b) applying the PRISMA approach for article screening. The initial search yielded 5,205 relevant articles. The findings indicate that Telegram users can leverage various advanced features to support their daily activities, including in education. One standout feature is Telegram BOT, which has been proven to effectively respond to user queries and commands, as shown in the study by Soeroso, Afrianto, Mayangsari, and Taali (2017). The implications of this research suggest that Telegram holds great potential as an interactive learning tool, particularly in supporting virtual mathematics instruction. Furthermore, Telegram's adaptability and ease of use make it an accessible option for teachers and students. Future studies are encouraged to explore its integration with other educational technologies to enhance learning outcomes.

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1. Introduction

Mathematics is a branch of science that plays a crucial role in human life (Lubashevsky & Lubashevsky, 2017). It not only involves numbers and calculations but also enhances logical thinking, pattern recognition, and decision-making skills, which are essential for solving real-life problems (Febriayanti & Irawan, 2017). However, mathematics education in schools often faces challenges due to time constraints, leading to less effective delivery of learning materials (Atweh et al., 2023; Mukuka et al., 2021). This limitation impacts students, as mathematics learning goals may not be fully achieved. Typically, students have only four hours of mathematics instruction per week, which contrasts sharply with their abundant free time outside of school, where they often engage in resting and playing (Findell et al., 2001). For the millennial generation, these activities frequently involve technology, particularly gadget-based games (Marpaung, 2018). The rapid advancement of technology has made gadgets an integral part of daily life for both children and adults, consuming much of their free time (Supriyadi & Taban, 2024). This trend presents an opportunity for students to leverage digital technology by utilizing

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applications like Telegram as a learning tool. Specifically, Telegram can serve as an Information and Communication Technology (ICT)-based platform that enables students to explore various subjects, including mathematics.

Telegram can function as a virtual teacher in mathematics learning, offering several advantages not found in other applications (González et al., 2021). It is practical, easily accessible, efficient, and equipped with AI features that assist users in managing their daily tasks (Widiyono, 2021). These AI features can also help students learn mathematics independently by providing not only answers to their questions but also explanations of the material and examples of related problems (Brown & Camptioone, 2013). This ease of access to information allows students to engage in self-directed learning through ICT-based educational tools (Lee et al., 2014). Moreover, telegram can serve as a communication medium, enabling teachers to create group chats with their students and distribute learning content.

Despite its many advantages, integrating Telegram into mathematics education also poses several challenges. One major concern is ensuring that the platform promotes deep learning rather than merely facilitating passive information delivery. To maximize its potential, educators need to adopt pedagogical strategies that foster critical thinking, problem-solving, and active participation among students. Simply using Telegram as a communication tool is insufficient; the content shared and interactions facilitated must be designed to engage students intellectually and encourage them to apply mathematical concepts to real-world problems. Furthermore, the success of using Telegram in education depends on the digital literacy of both teachers and students. Teachers must be proficient in utilizing the app's advanced features, such as creating BOTs, designing quizzes, and effectively managing large group discussions. Simultaneously, students need to be comfortable with using the app for learning purposes, which may require additional training or support. Telegram is a mobile application developed for communication purposes. The widespread use of mobile devices has great potential for e-learning in terms of pervasiveness, ubiquity, personalization, and flexibility (Aghajani, 2018). Surprisingly, this mobile app is also being used to reduce the spread of COVID-19 during school closures. Aghajari and Adbo (2018) used Telegram, one of the most popular social networking applications with millions of educational users, in their research to compare its efficacy with more conventional methods. They found that participants in the telegram cooperative writing group showed slightly higher scores compared to the conventional method.

During the COVID-19 pandemic, the Telegram mobile application was also used as a solution for the teaching and learning process in the education sector in other countries. Iqbal et al (2020) show that Telegram provides an effective mobile learning platform for medical students during COVID-19 and has fewer potential drawbacks, such as information running through notifications. Further research reveals that Telegram has become one of the most popular online social media networks among students (Mashhadi and Kaviani 2016) Telegram has channels and bots to access information with teachers. The use of Telegram as a learning medium based on information and communication technology can be utilized by users as a virtual teaching assistant, which makes it easier for users to complete their daily work (Hirzan, 2024). Wiranegara and Hairi (2020) used three techniques for implementing teaching and learning telegrams to achieve the objectives of their research, namely a) pre-teaching (preparation for group learning telegrams), b) during teaching, and c) post-teaching. After implementation, they concluded that the Telegram social media group learning strategy could be developed to involve and encourage students to be active in the teaching and learning process.

In light of the aforementioned considerations, the researchers are interested in investigating how Telegram functions as a virtual teaching tool in mathematics education. The research employs a systematic literature review method, which helps researchers better understand the topic, particularly in examining Telegram as a virtual teaching assistant. To achieve the research objectives, the following research questions are posed: (a) what types of research methods are used in studies that discuss Telegram as a virtual teaching assistant in mathematics education? (b) how is Telegram implemented as a virtual teaching assistant, and what mathematical skills are developed through its use in mathematics education?

2. Method

This research uses the systematic literature review (SLR) method. The goal of this method is to identify, review, and evaluate all research that is relevant to the researcher's question. Through this

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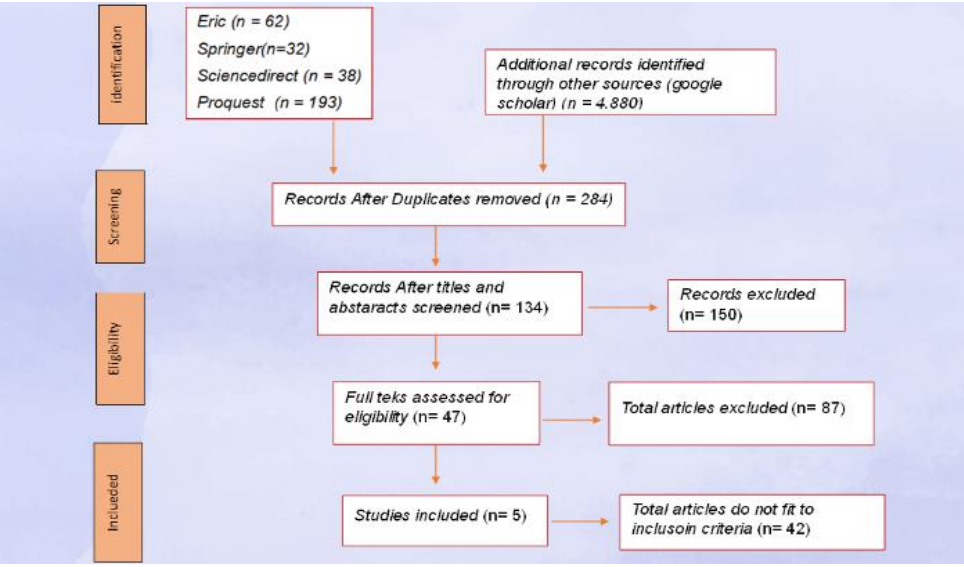
systematic literature review method, researchers will also obtain the main problems, produce a research framework, and researcher answers, which will enable researchers to produce more effective research (Suhartono, 2017). In this research, a systematic review is intended to provide answers to researchers' questions about how the Telegram application can be a teaching medium or teaching assistant in mathematics learning.

This research has several stages, including a) formulating the problem: the researcher writes a problem formulation that will be discussed in depth based on the needs of the topic chosen in this research, the researcher uses the PRISMA approach in the next stage, b) searching for literature (identification): the flow of the approach The first PRISMA is to search for articles that are relevant to the selection of research topics, the search process uses several websites, namely *Google Scholar*, ProQuest, Springer, ScienceDirect, and Eric with the keywords "telegram" and " virtual teaching".

From the initial research results, a total of 5,205 articles were obtained, c) the next stage was screening: the researcher filtered the same articles from several search websites and after being sorted there were 284 of the same articles, d) Eligibility: at this stage, the excluded process was carried out for articles that do not meet the researcher's criteria, the total remaining articles after going through this stage are 47 articles, e) included: at this stage articles are selected that discuss mathematics education and research objectives by the researcher's objectives, so that there are 5 articles obtained. For more clarity, look at the image below.

Figure 1

PRISMA systematic literature review.



The flowchart illustrates the systematic process of conducting a literature review based on the PRISMA framework, beginning with the identification stage. In this phase, relevant articles were collected from four databases: ERIC (62 articles), Springer (32 articles), ScienceDirect (38 articles), and ProQuest (193 articles), totaling 325 records. Additionally, 4,880 articles were found through other sources like Google Scholar. After collecting these articles, duplicates were removed, resulting in 284 unique records that moved to the next phase.

In the screening stage, the titles and abstracts of the 284 records were reviewed to determine their relevance to the research topic. During this process, 150 articles were excluded, leaving 134 articles for further consideration. These remaining articles were then subjected to a more in-depth review, with the full text of 47 articles assessed for eligibility. Finally, in the eligibility and inclusion stages, the 47 full-text articles were closely analyzed against predefined inclusion criteria. As a result, 42 articles were excluded for not meeting the criteria, leaving only 5 studies that were deemed suitable for the systematic review. This careful process ensured that only the most relevant and high-quality research was included in the final analysis.

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3. Results and Discussion

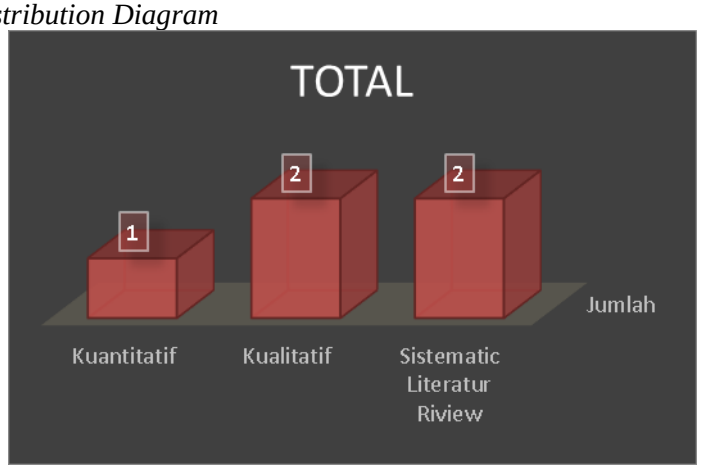
Research methods used in journals discussing telegram as a virtual teaching assistant in mathematics education

Based on the researcher's analysis of the five selected articles, it was found that these studies employed various research methods. Two articles utilized qualitative methods, specifically the works of Silvia et al. (2023) and Yakubu et al. (2024). These studies focused on in-depth, descriptive analysis of data, often relying on interviews, observations, or other non-numerical data to explore the research questions. In contrast, one article by Machaba-Bedada (2022) employed a quantitative method, which involved the collection and analysis of numerical data to test hypotheses or draw statistical conclusions. This method is often used for measuring and analyzing variables to determine relationships, trends, or differences within a given dataset.

The remaining two articles, authored by Jamika (2023) and Sarah (2023), adopted the systematic literature review (SLR) method. This approach involves a comprehensive and structured review of the existing literature on a specific topic, following a rigorous process to identify, evaluate, and synthesize relevant research. The use of these three distinct methods—qualitative, quantitative, and SLR—highlights the diverse approaches researchers take to examine issues within the field. An illustration of these methods can be seen in the diagram below.

Figure 2

Research Method Distribution Diagram



The Telegram application, while not equipped with built-in mathematical capabilities such as a calculator or direct math solver, offers significant potential for mathematics education through the use of BOTs and AI tools available within the platform. Users of Telegram can leverage these BOTs to access mathematical formulas, engage in discussions about questions they wish to learn, and ultimately utilize them as virtual teaching assistants.

Among the Telegram BOTs commonly used for enhancing mathematics learning are Basicmathbot and Math Teacher Bot. These BOTs serve as valuable resources, helping students grasp mathematical concepts and solve problems effectively. In addition to these two, there is a wide variety of other BOTs available that cater to different subject areas and educational needs, demonstrating the versatility of Telegram as a learning platform.

The mathematical capabilities offered through the Telegram application can be summarized as follows:

a) Comprehensive Explanations: The mathematics BOTs provide detailed explanations of the questions posed by users, along with step-by-step guidance on how to solve them. This ensures that users not only receive answers but also gain insight into the problem-solving process.
b) Conceptual Definitions: These BOTs offer various definitions of the mathematical concepts being inquired about, which aids in the understanding of the material. By encouraging users to think creatively and critically, they foster a deeper engagement with the content.
c) Basic Arithmetic Calculations: The BOTs in the Telegram application are capable of performing fundamental arithmetic operations, including addition, multiplication, subtraction, and division. This feature allows users to quickly verify their calculations without needing a separate calculator.

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d) Graph Plotting Abilities: Some BOTs can plot graphs of different types of mathematical functions, such as linear, exponential, and trigonometric functions. This visual representation helps users better understand the behavior of mathematical relationships.
e) Statistical Calculations: Telegram BOTs can also execute basic statistical analyses, allowing users to determine measures such as the mean, median, and standard deviation. This functionality is particularly useful for students studying statistics or data analysis.

Implementing Telegram BOTs as Virtual Teaching Assistants

a) To utilize Telegram BOTs as virtual teaching assistants, users can simply access the Telegram application and search for a BOT that aligns with their specific learning needs. For example, they might look for Basicmathbot, add it to their contacts, and begin using it immediately for assistance. The responses provided by the BOT will correspond to the commands submitted, facilitating an interactive learning experience.
b) By integrating these BOTs into their study routines, users can effectively engage in self-directed learning supported by Information and Communication Technology (ICT). This approach allows learners to explore mathematical concepts at their own pace, reinforcing their understanding and fostering a sense of independence in their educational journey.
c) In conclusion, the implementation of Telegram as a platform for mathematical learning, through its various BOTs, empowers students to enhance their mathematical abilities. By providing comprehensive support and resources, these virtual teaching assistants can play a crucial role in improving mathematics education and making learning more accessible and engaging for all users.

Discussions

Based on the research findings mentioned above, it is evident that Telegram users have access to a variety of advanced features that can significantly aid in their daily activities, particularly in the field of education. A study conducted by Soeroso et al (2017) highlighted that Telegram BOTs are capable of accurately responding to users' questions and commands through their robust search functionalities. The implementation of such Telegram BOTs has proven to have a positive impact on both school students and university learners. This assertion is supported by research from Widiyono (2021), who noted a highly significant influence on learning activities when Telegram is utilized as an educational medium.

The efficiency with which Telegram BOTs deliver answers to user commands is emphasized in the study by Sari et al. (2020). Their research found that this quick response capability provides time savings for users, allowing them to complete tasks more efficiently. Given these advantages, the choice of the Telegram application as a virtual teaching tool for mathematics is well-founded. Research conducted by Parlika et al (2020) supports this assertion, demonstrating that Telegram's features facilitate the calculation of formulas for plane shapes and geometric figures. This capability assists students in understanding and applying mathematical concepts more effectively.

Moreover, the versatility of Telegram extends beyond mathematics, making it applicable in various subject areas. For example, a study by Alhabib, Cahyani, and Saadie (2020) revealed that Telegram serves as an effective medium for teaching short story writing in language lessons. Their findings indicated that the use of Telegram in this context led to a significant increase in average student scores, demonstrating its effectiveness in enhancing learning outcomes. Overall, employing Telegram as a learning medium provides several advantages, including time efficiency, practicality, simplicity, and rapid access to information. By harnessing the capabilities of Telegram BOTs, educators can create an engaging and supportive learning environment across a range of subjects, thereby enhancing the educational experience for students.

Recommendations

The use of Telegram application can be used as an ICT (Communication Science and Technology) based learning medium to have a positive impact on its users. The learning available on the Telegram BOT is so diverse that users will only choose the Telegram BOT that suits their needs. This research only focuses on the use of telegram BOTs, therefore, researchers recommend that further research be about how to create or create telegram BOTs that can help teachers carry out learning by the existing curriculum in their country.

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4. Conclusion

Telegram, as a virtual learning platform, can significantly assist its users in completing various daily tasks related to education. Telegram BOTs provide a wide range of functionalities across diverse learning fields. Specifically in mathematics, Telegram BOTs are capable of solving complex mathematical formulas, offering detailed concept explanations, as well as generating and displaying graphs according to user instructions. This enables students and educators to interact with mathematical problems more dynamically and visually. Furthermore, Telegram BOTs are not limited to mathematics; they are also available in other fields such as language learning, science, technology, and many others. These BOTs allow users to access educational content more interactively and efficiently. With the ability to deliver instant feedback, offer step-by-step solutions, and enhance distance learning experiences, Telegram BOTs have become powerful tools in supporting the teaching and learning process across multiple disciplines. Their integration into virtual learning environments has the potential to streamline education and provide valuable resources for both students and educators. In conclusion, Telegram as virtual teaching can help its users complete their daily work. Telegram BOTs are available in various learning fields, one of which is in the field of mathematics, Telegram bots can solve mathematical formula problems and provide concept illustrations and graphs in mathematics according to the user's instructions. Not only in mathematics learning, Telegram BOT is also available in language learning, science, and so on.

Limitations

Despite the advantages of using Telegram and its BOTs in virtual learning, several limitations need to be acknowledged. First, the reliance on internet connectivity poses a challenge, particularly in areas with limited or unstable access. Users in such regions may experience difficulties in utilizing Telegram BOTs effectively for educational purposes. Second, while Telegram BOTs can solve mathematical problems and provide visual aids, they cannot offer personalized explanations or adapt to individual learning needs, which may limit their effectiveness for students who require more detailed guidance. Third, Telegram BOTs are largely dependent on the instructions given by the users, meaning that they may not always provide comprehensive solutions or address more complex educational queries. Lastly, the security and privacy of user data could be a concern, especially in educational contexts, where sensitive information may be shared. These limitations suggest that while Telegram BOTs are useful tools, they should be complemented with other instructional methods to ensure a more holistic and personalized learning experience.

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Author Contribution

Aprianah Puspa Sari Dewi: Conceptualization, Writing - Original Draft
Ema Linda Wahyuni: Review & Editing
Moh. Rizal: Methodology, Formal Analysis
Muhamad Galang Isnawan: Validation and Supervision
Imam Fakhrurrozi: Validation and Supervision

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Conflict of Interest
The authors declare no conflict of interest.

Additional Information:
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