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RESEARCH ARTICLE

Optimizing Mathematics Learning for Children with Autism Using Flashcard Approach

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ABSTRACT

Education for autistic children requires a specialized approach that can accommodate their unique needs. Children on the autism spectrum often face challenges in understanding abstract concepts, including math. Therefore, visual and repetitive learning methods, such as the use of flashcards, can be an effective tool in helping them. This study aims to contribute to a more comprehensive and in-depth understanding of the use of flashcards in math education for children with autism, as well as provide better recommendations for future educational practices and policies. Research Design The research used an in-depth qualitative case study design to explore the role of flashcards in improving math comprehension in children with autism. The research focused on direct observation and interaction during the learning process. The research subjects consisted of two children on the autism spectrum aged between 6-10 years old. Both children were enrolled in an inclusive primary school and each was accompanied by one special assistant teacher (SETAs). The selection of subjects was done by purposive sampling based on the diagnosis of autism and approval from the teacher. Research Instruments The instruments used in this study include Math Flashcards, Classroom Observation, and Special Assistance Teacher (SETAs) Interviews. Data Collection Techniques using Direct Observation, Semi-Structured Interviews. Data Analysis Techniques using Qualitative Analysis Techniques, namely Data from observations, and interviews, will be analyzed using thematic analysis techniques to identify patterns and themes that arise in responses and behavior. Descriptive Analysis Techniques are used to describe the characteristics of research subjects and the results of observations and interviews. The results revealed that using flashcards as a visual aid significantly improves math comprehension in children with autism, and helps increase the active involvement of children with autism in the learning process. The results of this study provide empirical evidence supporting the use of flashcards as an effective tool in mathematics education for children with autism.

INTRODUCTION

Education for children with autism requires a specialized approach that can accommodate their unique needs. Children on the autism spectrum often face challenges in understanding abstract concepts, including math. Therefore, visual and repetitive learning methods, such as the use of flashcards, can be an effective tool in helping them. Special education for children with autism is one area that requires extra attention in the education system. Children on the autism spectrum often face significant challenges in terms of communication, social interaction, and cognitive abilities, including understanding abstract concepts such as math (Mustafa et al., 2016). These challenges require innovative and effective teaching methods to ensure that they can obtain an education on par

with their peers who do not have the condition. One method that is gaining popularity is the use of flashcards in math learning.

Flashcards are simple yet highly effective visual aids in conveying information. They can help clarify complex concepts in a way that is easy to understand. Research has shown that children on the autism spectrum are often more responsive to visual-based learning compared to verbal learning methods (Mustafa et al., 2021). Therefore, the use of flashcards that emphasize repetition and visualization of information can be a very useful tool in mathematics education.

Many studies have underlined the importance of visual-based approaches in the education of children with autism. According to research by Smith et al. (2019), children with autism tend to process visual information more effectively than verbal information. This makes flashcards a very suitable tool for teaching math, where many concepts can be more easily understood through visual representations. The use of visual aids can help children with autism develop their cognitive skills (Gultekin and Kose, 2018).

In addition, flashcards can be used to reinforce memory and repetition skills which are very important in math learning. Children with autism often need more time and repetition to learn new concepts. In this context, flashcards offer an efficient way to provide the necessary repetition without making the child feel bored or overwhelmed. Research by Jones and Carr (2020) showed that the use of flashcards in math teaching can improve information retention in children with autism. The study found that children taught using flashcards showed significant improvement in understanding and mastery of basic math concepts compared to those taught using conventional methods. In addition to improving comprehension, the use of flashcards can also help develop other cognitive skills such as attention, concentration, and the ability to follow instructions. Children with autism often face difficulties in maintaining their attention for long periods. Attractive and interactive flashcards can help maintain their interest and engagement in the learning process.

The use of flashcards in the education of children with autism also has important implications for educational inclusion. By providing an effective tool for teaching math concepts, flashcards help to ensure that children with autism can learn in a more inclusive environment and not be separated from their peers. This is in line with the goal of inclusive education promoted by many countries and international education organizations. As a flexible tool, flashcards can be adapted to the individual needs of each child. This is very important as autistic children have different levels of severity and needs. By using customized flashcards, educators can create personalized learning programs that are more effective and efficient in meeting the needs of each child.

This research is very important for several fundamental reasons. First, autistic children often face unique challenges when it comes to education, particularly in understanding abstract concepts such as math. Conventional learning methods may not always be effective for them, so a more adaptive and specific approach is needed to meet their needs. Secondly, flashcards as visual aids are effective in aiding learning in children with various special needs. However, specific research focusing on the effectiveness of flashcards in improving math comprehension in children with autism is limited. By conducting this study, we can obtain solid empirical data on how flashcards can be optimally used in special education contexts. Third, the importance of this research also lies in the effort to create inclusive education. Inclusive education seeks to provide equal opportunities for all children, including those with special needs, to learn and develop in a supportive educational environment. Flashcards as a flexible and adaptable tool can be one of the solutions to achieving this goal, ensuring that autistic children can learn together with other children

This study may also pave the way for further research in the field of special education. By better understanding how visual aids such as flashcards affect autistic children's learning, researchers can explore other ways to improve educational outcomes, including the development of other visual aids or more sophisticated learning approaches that combine technology and evidence-based interventions. In the context of research on the use of flashcards in learning mathematics for children with autism, several gaps between this research and previous research need to be identified and explained, namely: (1) previous research has demonstrated the effectiveness of flashcards in improving learning in children with various special needs. For example, Smith et al. (2019) found that children with autism were more responsive to visual-based learning, including flashcards,

compared to verbal methods, whereas the research in this article focuses more on the general response to visual aids without giving specific emphasis on math learning. Thus, a gap exists in the lack of specific focus on how flashcards can be used to improve math comprehension in children with autism, (2) research by Jones and Carr (2020) highlighted the use of flashcards in math instruction for children with autism and found improvements in information retention. However, this study may not have included variations in the approach to flashcard use, such as frequency of use, type of content presented, and interactions between teachers and students, whereas the research in this article aims to explore more deeply these variations and how each factor affects learning outcomes, (3) most previous studies focus on short-term measures of flashcard effectiveness. These studies usually evaluate children's math comprehension immediately after the intervention without considering the long-term impact, whereas the research in this article aims to fill the gap by evaluating not only the short-term outcomes but also the long-term impact of using flashcards in math learning in children with autism. This will provide a more comprehensive picture of the effectiveness of this method in supporting ongoing academic development. Research by Karal and Wolfe (2018) shows that visual aids such as flashcards can help children with autism understand more complex math concepts. The use of flashcards can also help them in improving their critical thinking skills, research by Jones et al. (2019) revealed that visual aids such as flashcards can encourage children with autism to develop critical and analytical thinking skills.

This study aims to contribute to a more comprehensive and in-depth understanding of the use of flashcards in mathematics education for children with autism, as well as provide better recommendations for future educational practices and policies.

RESEARCH METHODS

Research Design

This research used an in-depth qualitative case study design (Yin, 2019; Cresweel, 2018) to explore the role of flashcards in improving math comprehension in children with autism. Qualitative case studies provide deep insights into how this teaching method affects the learning ability of children with autism in a real context. Ghafourian and Zarei (2020) research shows that qualitative approaches, particularly case studies, are highly effective in exploring teaching practices and learning outcomes among students with special educational needs. This is supported by Lentz et al. (2019), Nash et al. (2021), Terrell (2023), Mustafa et al. (2023) that the qualitative case study design allows researchers to dig deeper into how visual aids, including flashcards.

This study focuses on direct observation and interaction during the learning process. Each research subject will receive an explanation of the use of flashcards, followed by a learning session implemented in daily classroom activities. This approach allows the researcher to understand in depth how flashcards affect math comprehension in each child.

Research Subject

The subjects of this study consisted of two children on the autism spectrum aged between 6-10 years old. Both children were enrolled in an inclusive primary school and each was accompanied by one special assistant teacher. The subjects were selected by purposive sampling based on the diagnosis of autism and consent from the teacher.

Research Instruments

The instruments used in this research include (1) Mathematics Flashcards, which are cards containing pictures and numbers to teach basic mathematical concepts such as addition, subtraction, and recognition of geometric shapes, (2) Classroom Observation Sheets used by researchers to record children's behavior and responses during learning sessions, and (3) Interviews with Special Education Teacher Assistants (SETAs) to gather data on children's development and responses during learning sessions using flashcards.

Data Collection Techniques

Data collection is done through (1) Direct Observation, conducted during learning sessions to observe children's interactions with flashcards and their responses to the material being taught. This

observation will note how children use flashcards, the difficulties they face, and the progress made, (2) Semi-Structured Interviews, interviews with special education teacher assistants to gain insight into their experience using flashcards and the developments they see in children.

Data Analysis Techniques

Data analysis is done using: (1) Qualitative Analysis Techniques, where data from observations and interviews are analyzed using thematic analysis to identify patterns and themes that emerge in children's responses and behaviors during the intervention, and (2) Descriptive Analysis Techniques, used to describe the characteristics of research subjects and the results of observations and interviews.

Data Validity

To ensure data validity, several steps will be taken: (1) Member Checking: Involving special education teacher assistants to verify researchers' findings and interpretations, (2) Peer Debriefing: Discussions with fellow researchers to gain feedback and improve the objectivity of the analysis.

RESULTS

This study was conducted in an inclusive primary school in Makassar city, South Sulawesi, where two children on the autism spectrum were selected as research subjects. Each child was accompanied by a special assistant teacher (SETAs) who had understood the use of flashcards for math learning. The research process began with an explanation to the children and the accompanying teacher about the purpose and method of using flashcards in math learning. Each learning session was conducted individually for about 30 minutes per session and was held once a week for one month. During the learning session, children were introduced to flashcards containing pictures and numbers to teach basic math concepts such as addition, subtraction and geometry shape recognition. Observations were conducted directly by the researcher to record children's behavior and responses during the learning sessions. Semi-structured interviews with the accompanying teachers were conducted after some sessions to gain further insights into the children's development and the effectiveness of the flashcards.

1. Direct Observation Results

Observations were made by recording learning activities, following the description of the observation results.

Figure 1. Geometric Shape Identification

Figure 1 shows the autistic student and SETAs sitting at a table, with their faces hidden for privacy. On the table, there are cards, each with a different colored square in red and its color name in Bahasa Indonesia (Square, Rectangle, Parallelogram, Circle, and Triangle). This activity is interesting because it is in an educational setting where the concept of basic geometric shapes and their names in Bahasa Indonesia is taught or reviewed. This interactive learning method through matching exercises can help in understanding the concept of language and geometry shapes. The steps taken by autistic students in identifying geometric shapes based on the picture above:

Table 1. Student Activities Identifying Geometric Shapes

Geometry	Student Activity
Square	1. Students look for shapes with four equal sides and four equal angles. 2. They check if there is a shape that meets these criteria
Rectangle	1. Students look for shapes with two pairs of parallel sides and different lengths. 2. They compare the sides to identify the rectangle.
Circle	1. Students look for shapes that have circular edges. 2. They check if there are shapes with edges that form a circle.
Triangle	1. Students look for shapes with three sides. 2. They check if there are shapes that have three sides.
Parallelogram	1. Students look for shapes with two pairs of parallel sides. 2. They compared the sides to identify the parallelogram.
Trapezoid	1. Students look for shapes that have one pair of parallel sides and two non-parallel sides. 2. They check if there are forms that meet these criteria.

The technique used by teachers to develop the use of flashcards in learning geometric shapes is **Visualization with Pictures**. Visualization helps autistic children remember shape characteristics better. Visualization involves using pictures or visual representations to help them understand the characteristics of geometric shapes. The teacher shows pictures of geometric shapes using flashcards.

Addition and subtraction flashcards follow

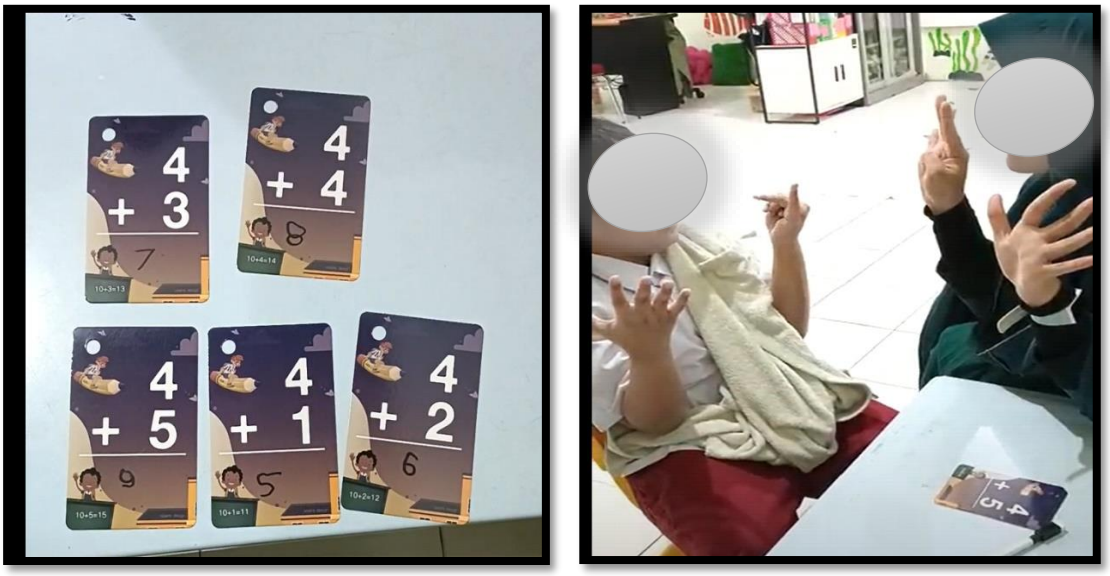

Figure 2. Addition using Flashcards

Figure 2 shows the interaction between the child with autism and the teacher in learning to count sums. The flashcards on the table are used to teach addition facts, and the teacher's role is to show the cards with numbers and ask the students to answer quickly. The teacher introduces terms such as "all," "together," "how many," "total," and "sum." These terms indicate that the student has to add two or more numbers. The fingers raised by the student indicate the numbers to be added, i.e..... The student holds up 4 fingers on one hand, and 5 fingers on the other hand and then counts while closing each of the fingers that have been held up until the count of nine, the sum is written on the flashcard, which is:

Figure 3. Addition using Flashcards

Figure 3 shows a teacher helping a student count the numbers on flashcards. The teacher holds the child's hand gently, perhaps providing support or guidance. This interaction demonstrates an empathic and caring approach to the autistic child's needs, and illustrates a positive learning moment between the teacher and the student. In this situation, the teacher helps a child with autism who has

difficulty using his fingers to count. Support and guidance from the teacher is essential in ensuring they understand math concepts well.

Figure 4. Subtraction using Flashcards

Using fingers as physical aids can help autistic children understand the concept of subtraction in a more concrete and visual way. Autistic children use both hands to represent numbers. Numbers are broken down into (represented by all fingers on both hands) and (represented by five fingers on one hand). The teacher's role is to help the autistic child focus and explain while pointing out what we need to subtract from. The child starts counting with the hand that represents the number , then the teacher asks him to lower finger from one hand that represents five units, and lower one finger from the other hand that represents tens. After the child has lowered 6 fingers, the teacher instructs them to count the remaining fingers. The student has remaining fingers (fingers from one hand and fingers from the other hand), so the result is. The subtraction result is written on the flashcard:

Each autistic child has unique needs, so during the learning process teachers pay attention to appropriate responses and adaptations. Using fingers as physical aids can help autistic children understand the concept of subtraction more concretely and visually. The role of the teacher is to provide support and guidance throughout this process, as well as praise and positive reinforcement for each successful step.

During the learning sessions using flashcards, some key findings can be identified:

a) Improved Attention and Concentration: Children with autism showed improved attention and concentration when using flashcards compared to conventional teaching methods. They seemed more interested and focused when learning math concepts presented in visual form.

b) Better Interaction: The use of flashcards facilitates better interaction between the student and the special assistant teacher. The autistic child was more active in asking and answering questions when using flashcards, indicating increased engagement in the learning process

c) Understanding of Math Concepts: Both autistic children showed a better understanding of basic math concepts such as addition, subtraction, and recognition of geometric shapes. Flashcards helped them understand and remember these concepts more effectively through clear visualization.

d) Positive Response to Visualizations: Children showed a very positive response to the visualization provided by flashcards. They find it easier to understand and remember information presented visually compared to verbal information.

2. Interview Results with Special Assistance Teacher (SETAs)

The interview with the SETAs revealed some important insights:

a) Effectiveness of Flashcards: SETAs report that flashcards are very effective in helping children understand math concepts. They noted significant improvements in children's ability to understand and apply the concepts taught.
b) Child Engagement: SETAs also reported that children were more engaged and motivated when using flashcards.
c) Individualized Customization: Flashcards allow for greater individualization, allowing teachers to customize materials according to each child's needs and abilities. This helps to create a more inclusive and effective learning environment.
d) Ease of use: SETAs found the flashcards easy to use and integrate into the learning curriculum. They feel this tool is a valuable addition to their teaching methods.

DISCUSSION

Analysis of data from observations and interviews showed that the use of flashcards in math learning had a significant positive impact on the comprehension of children with autism. The qualitative data obtained indicated several key themes:

a) Improved Concept Understanding: Autistic children show a better understanding of basic math concepts. Flashcards help them overcome difficulties in understanding abstract concepts through clear and repeated visualizations.
b) Motivation and Engagement: Flashcards increase autistic children's motivation and engagement in the learning process. They showed greater interest and participated more actively when using flashcards.
c) Positive Interactions: The use of flashcards facilitates more positive interactions between children and specialized support teachers, creating a more inclusive and supportive learning environment.

This study reveals that the use of flashcards as a visual aid has a significant impact in improving math comprehension in children with autism. Children with autism often face challenges in understanding abstract and symbolic concepts common in mathematics. Flashcards, with their clear and concrete visualizations, help overcome these challenges by providing a visual representation that is easier to understand.

Flashcards allow autistic children to see and touch the information they are learning, providing an important multisensory learning experience. This is in line with Kunda and Goel's (2020) research, which shows that visual approaches can be particularly effective for autistic children who tend to have strengths in visual processing. In addition, flashcards can be used individually or in small groups, allowing for a more personalized and interactive approach to learning.

The use of flashcards also helps in strengthening memory. By repeating the same information through various flashcards, they can develop stronger long-term memories. Schopler et al. (2019) and Mustafa (2016) confirmed that repetition is key in helping autistic children remember new information, and flashcards provide an effective way to achieve this. In addition, flashcards can improve their concentration during the learning process. Autistic children often struggle to maintain their attention, and visual aids such as flashcards can help maintain their focus on a given task. White et al. (2010) found that visual and interactive aids can increase autistic children's engagement, making them more focused and involved in the learning process.

The results of this study also found that flashcards help in increasing autistic children's active engagement in the learning process. By holding and flipping the flashcards, they are more physically and mentally engaged, which is especially important for those who may need additional stimulation to stay engaged. This allows them to learn in a more dynamic and interactive way. The use of flashcards also allows for individualization in learning. Each autistic child has unique needs and ways of learning, and flashcards can be customized to meet those needs. Parsons et al. (2021) point out that a customized approach is essential in the education of autistic children, and flashcards provide

the necessary flexibility to adjust the level of difficulty and type of content according to each child's ability.

In Indonesia, research on the use of flashcards in the education of children with autism has also shown positive results. A study conducted by Widya and Prasetyo (2020) found that the use of flashcards can help those in primary school in understanding basic math concepts such as numbers and simple operations. The results of this study support international findings that visual aids play an important role in the education of children with special needs.

In this study, it was also found that support from special assistant teachers was instrumental in helping autistic children maximize the benefits of using flashcards. Simpson et al. (2019) emphasized the importance of collaboration between teachers, parents and other education professionals in creating a supportive learning environment for children with autism. The use of flashcards also encourages active participation from children which is crucial for their learning. They often need additional stimulation to stay engaged, and flashcards provide an interactive and engaging way to learn. By holding and flipping flashcards, children are more engaged in the learning process, which helps them understand and remember information better. In the context of inclusive education, flashcards can be used as a tool to integrate children with autism into the regular classroom. By using visual aids such as flashcards, teachers can help them to more easily follow lessons and participate in classroom activities. This supports the goal of inclusive education, where all children, including those with special needs, have equal access to education.

In addition, the use of flashcards can help in developing the social skills of children with autism. By working in small groups and using flashcards, children can learn to interact with peers and develop communication skills. This is in line with the research findings by White et al. (2010), which showed that interactive aids can help children with autism in developing social skills.

In this study, it was also found that the use of flashcards can help in improving the logical thinking and problem-solving abilities of children with autism. By using flashcards to solve math problems, children learn to think systematically and logically, which are important skills in everyday life. The use of flashcards can help children with autism in developing fine motor skills. By holding and flipping flashcards, children practice their motor skills, which are important for everyday tasks like writing and drawing. In the context of education in Indonesia, the use of flashcards as visual aids in the education of autistic children has received support from various parties. Widya and Prasetyo (2020) emphasize the importance of innovation in teaching methods for children with special needs, and flashcards are one of the tools that are effective and easy to implement in various schools. Flashcards can help autistic children understand order and structure in math. They often have difficulty understanding the sequence of steps in solving math problems. By using flashcards that display each step separately and clearly, they can learn to follow the sequence more easily. This is supported by the findings of Barik et al. (2021), who showed that a step-by-step approach is helpful for children with autism in understanding and solving math problems. In addition, flashcards can be used to teach the concept of time and sequence of events. Children with autism often have difficulty in understanding time concepts, such as the order of days of the week or hours. By using flashcards that display the sequence of events or time, children can learn to understand and remember these concepts better. Research by Sahin et al. (2020) showed that the use of visual aids can improve children with autism's understanding of time and sequence concepts.

Flashcards can also help autistic children develop communication skills. By using flashcards that feature pictures and words, they can learn to recognize and use words in the correct context. This is important as many autistic children have difficulties in verbal communication skills. The study by Tager-Flusberg and Kasari (2019) showed that visual aids can help children with autism in developing their communication skills.

The use of flashcards can also help in reducing autistic children's anxiety during the learning process. They often feel anxious or depressed when faced with difficult or unfamiliar tasks. By using flashcards, they can learn in a more structured and predictable environment, which can help reduce their anxiety. Research by Wood et al. (2020) showed that the use of visual aids can help reduce anxiety and increase autistic children's comfort during the learning process.

In the context of inclusive education in Indonesia, the use of flashcards as visual aids is crucial to ensure that children with autism receive an equal and inclusive education. According to research by Fauziah and Ramadhani (2019), the use of visual aids such as flashcards can help autistic children to more easily follow lessons in regular classes and participate in classroom activities. This is important to achieve the goal of inclusive education in Indonesia. The use of flashcards can help in increasing the learning motivation of children with autism. Children with autism often have difficulty in maintaining their motivation during the learning process. By using engaging and interactive flashcards, children can feel more motivated to learn and complete their tasks. The study by Simpson et al. (2019) showed that the use of engaging visual aids can increase autistic children's learning motivation, and assist them in developing daily living skills (Sarika and Prakash, 2020), as well as help them in developing decision-making skills (Wang et al., 2021), better self-management skills (Macdonald et al. 2020), and are very effective in helping them understand and practice social skills in a safe and controlled environment (Bellini et al. 2018),

In the context of teaching math, flashcards can be used to teach geometry and measurement concepts. By using flashcards featuring geometric shapes and measuring tools, children with autism can learn to recognize and understand these concepts better. According to Widayati Et al. (2017) Children with autism have difficulty in understanding mathematical concepts and easily lose focus, so in teaching geometry teachers can connect the material with everyday contexts and use teaching aids. This is also supported by Roberts et al. (2019) who revealed that the use of visual aids integrates mathematics with everyday situations, so that it can improve the mathematical literacy skills of children with autism, as well as help them to see the relevance and practical application of the mathematical concepts they learn.

CONCLUSION

From this study, it can be concluded that flashcards have an important role in improving math comprehension in children with autism. These visual aids not only help in understanding concepts, but also strengthen memory, improve concentration, encourage active participation, and allow individualization in the learning process. The use of flashcards has a significant positive impact on improving math comprehension. Flashcards not only help students understand math concepts better, but also increase their attention, concentration and engagement in the learning process. In addition, flashcards facilitate better interaction between children and teachers, creating a more inclusive and effective learning environment. The results of this study provide empirical evidence supporting the use of flashcards as an effective tool in mathematics education for children with autism. It provides valuable insights for educators, therapists and parents in developing more adaptive learning strategies that suit the needs of children on the autism spectrum.

Authors' Contributions

Sriyanti Mustafa (author) is in charge of designing research designs, determining research methods, relevant literature, conducting research and is responsible for preparing research reports.

Baharullah (Co Author) is in charge of assisting in conducting literature reviews related to the research topic, assisting in determining research instruments and data collection techniques, collecting data carefully and managing the information obtained, and is responsible for compiling certain parts of the research report.

Khadijah maming (Co Author) is in charge of assisting the process of collecting relevant data in accordance with the established research methodology, processing and analyzing the data that has been collected, and is responsible for compiling certain parts of the research report.

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