Active Learning Barriers in Developing Mathematical Proficiency: Comparing Visual Impairment Students' and Teachers' Perspective

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Abstract

Visual impairment (VI) students face various barriers in mathematics learning, which cause low mathematical proficiency (MP). Therefore, active learning (AL) needs to be optimized to develop the MP of VI students in inclusive classes. This research aimed to explore the barriers of AL to developing MP from the perspectives of VI students and teachers. This was qualitative research with a case study design. The subjects were nine VI students and seven mathematics teachers from an inclusive high school in Yogyakarta. They were selected using purposive sampling. Semi-structured interviews were conducted to collect data. Data analysis was done using the Bogdan and Biklen approach. The result explores AL barriers to developing MP from the perspectives of VI students and teachers almost similar. It can be categorized into three themes: 1) human side barriers, mainly barriers are students' lack of confidence in their abilities and novice teachers' lack of confidence in facilitating VI students. This indicates that both of them have low self-efficacy; 2) environmental barriers, mainly related to discrimination and limited communication skills; and 3) technology and learning media barriers, mainly related to limited learning media for VI students' hands-on activities.

Keywords: barrier, active learning, visual impairment, perspective, mathematical proficiency

1. Introduction

1.1 Introduce the Problem

Visual impairment (VI) is one of the special needs conditions found in many countries. Data from the International Agency for the Prevention of Blindness (IAPB) shows that in 2020 around 1.1 billion people in the world are visually impaired from moderate to total blindness. Of these, 88 million were in the school-age range. The IAPB data also show that the global prevalence estimated for VI will increase to 1.7 billion in 2050. In line with these data, VI is the highest disability in Indonesia, which is 63.7% of all people with disabilities (Bappenas, 2021). These data make Indonesia the largest country with VI in Southeast Asia.

The high prevalence of VI implies the importance of support from various elements, particularly in education. However, special education and inclusive education practices still face many challenges in facilitating VI students (Limaye, 2016; Naude & Meier, 2019; Negash & Gasa, 2022). Some of the barriers found in inclusive education with VI students are lack of equipment, limited trained teachers, inappropriate resources, and limited collaboration between schools and stakeholders (Dagnew, 2013; Negash & Gasa, 2022). This condition shows the importance of improving inclusive education services for VI students.

VI students face various barriers to learning mathematics, especially those related to geometry and graphics (Sahasrabudhe & Palvia, 2013; Smith & Smothers, 2012). This is because vision is one of the main keys to supporting the development of students' mathematical concepts and procedures (Emerson & Anderson, 2018). In mathematics learning practices, the high reliance on visual instruction in the early stages is a barrier for them to develop mathematics skills to a higher level (Bell & Silverman, 2019). In addition, some studies have shown that learning practices provide fewer opportunities for VI students to develop advanced mathematics than sighted students (Bateman et al., 2018; Emerson & Anderson, 2018). Therefore, VI students can't optimally learn mathematics in inclusive classrooms.

The various learning barriers make VI students have low outcomes in mathematics compared to other academic subjects. They face various challenges in solving mathematical problems, such as understanding problems, mapping problem information to appropriate representations, and determining solutions (Dheesha, 2022). This condition needs to be solved because good mathematics skills are a requirement for success (Skagerlund et al., 2019). In addition, mastery of mathematics for students, including VI, is important because mathematics is a major component of science, technology, and engineering (Rozgonjuk et al., 2020). Low mathematics learning outcomes are predictors of low mathematical proficiency (MP) among VI students. This opinion is in line with research findings that show that 99.75% of high school students with high mathematics learning outcomes have high MP skills (Awofala, 2017).

Research on MP has been conducted at all levels of education, starting at the primary (Henry et al., 2014; Perez et al., 2018; Reardon & Galindo, 2007), secondary (Barrett et al., 2012), and high education levels (Allen & Pappas, 1999). This research confirms that MP is important for every student, including VI, at every level of education. Therefore, mathematics learning in inclusive classes needs to develop an MP for every student, including VI students. To develop MP, teachers need to promote appropriate learning methods (Groves, 2012). Samuelsson (2010) suggested that there are various learning methods for developing MP. Therefore, teachers need to design learning that can develop the MP of VI students in inclusive classes, one of which is through active learning (AL).

AL has been shown to provide many benefits in terms of improving academic achievement, positive attitudes, and student engagement in learning. One of these has been proven in research through group discussions (Ito & Takeuchi, 2021). It is widely assumed that learning can be transformed from traditional teacher-centered practices to student-centered active learning (Alhija, 2017). However, some research has proven that implementing AL in many schools is difficult (Cuban, 2013). Thus, the practice of AL, especially in inclusive classes, encounters various barriers that need to be resolved.

AL barriers, from the perspective of teachers and students, need to be explored. This can make a significant contribution to the development of AL. Through teachers' perception, they can see their thoughts and feelings, especially when defining their actions (Donker et al., 2021). Teachers' perspectives are ineffective if they are the only source of information in examining classroom processes (Karamane et al., 2023). This is because it is possible that teachers are not aware of what they have done (Scherzinger & Wettstein, 2019). Therefore, students' perspectives should also be explored to provide a more comprehensive explanation. Students' perspectives in the classroom are important because their experiences differ from those of their teachers. In addition, student perspectives are important because each student has different responses to learning (Hargreaves 2017). The results of this research will explore barriers to AL. It can help to determine the needs analysis in developing AL in inclusive classrooms and as a basis for mathematics teachers' professional development to teach in inclusive classes.

1.2 Research Question

Based on the explanation above, this study will explore and compare the perspectives of VI students and mathematics teachers related to AL barriers in developing MP in inclusive classes. This study answered two research questions.

1. What are the AL barriers to developing MP in inclusive classes from the perspective of VI students?
2. What are the AL barriers to developing MP for VI students in inclusive classes from the perspective of mathematics teachers?

1.3 Literature Review

1.3.1 Active Learning

Active student participation is key to successful learning. When students engage with the environment, they learn meaningfully rather than listening to the teacher's explanations (Schunk, 2012). Based on Dale's Cone of Experience, when students do real things or simulate the real experience in the learning process, not just passively listening, they have a better chance to remember 90% of the learning materials (Dale, 1946). In addition, student engagement in the learning process improves their communication skills, learning outcomes, and attention, and enhances their life skills (Banihashem et al., 2022). Therefore, the process of mathematics learning in inclusive classes must be accomplished by active learning (AL).

AL is derived from the constructivist theoretical framework. According to constructivism, learning is a personal construct based on students' experiences (Mogavi et al., 2021; Seo et al., 2017). AL refers to an instructional approach that actively engages students in the learning process through collaboration and discussion (Lee et al., 2018). This strategy simultaneously integrates intellectual, social, and physical engagement (Figure 1) to provide

students the opportunities for enjoyable experiences to develop their abilities (Edwards, 2015). The integration of these three components is important because the best learning outcomes are achieved when there is interaction between the intellectual, social, and physical environments (Edwards, 2015; Vale & Barbosa, 2023).

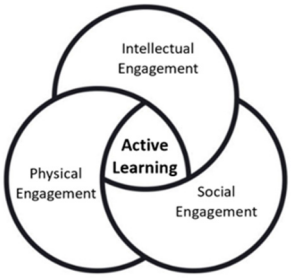

Figure 1. Active Learning Dimension

The concept used to illustrate student engagement involves facilitating students' communication, experimentation, interaction, investigation, production, and participation (Børte et al., 2023). AL has been proven for more than 30 years can make students more interested and keep them engaged in learning for longer periods (Bonwell & Eison, 1991). Some research has proven that AL can develop MP, for example by problem-solving (Samuelsson, 2010), inquiry learning (Al-Taie, 2019), open-ended learning (Irawan, 2018), and STEM (Elsayed, 2022; Rohimah et al., 2022). This shows an opportunity to use AL effectively to develop the MP of VI students in inclusive classrooms.

1.3.2 Mathematical Proficiency

One of the most important abilities for success in mathematics learning is MP. If a student has an MP, they will be proficient in solving math problems and have good math performance (Awofala, 2017; Samuelsson, 2010). Students can develop MP skills if they receive appropriate learning from their teacher (Groves, 2012; Sudiarta & Widana, 2019), learning resource support (Newton, 2021), and curriculum (Irawan, 2018). Therefore, mathematics learning in inclusive classes needs to strive to develop MP optimally.

MP describes the way students learn mathematics meaningfully and effectively (Kilpatrick et al., 2001). The MP includes five strands that are interrelated and integrated: (1) conceptual understanding, (2) procedural fluency, (3) strategic competence, (4) adaptive reasoning, and (5) productive disposition (Kilpatrick et al., 2001). To be proficient in mathematics, students must have a conceptual understanding (O'Connor, 2023). In addition, students need to have procedural fluency, including the ability to apply mathematical processes efficiently, precisely, and accurately (Rittle-Johnson & Alibali, 1999). Conceptual understanding and procedural fluency have a two-way relationship and have been previously studied (Rittle-Johnson et al., 2015). The next ability is adaptive reasoning, which refers to students' ability to justify and reflect on their understanding of mathematics. Strategic competence is students' ability to formulate and represent mathematical problems appropriately (Kilpatrick et al., 2001). Besides the four strands that focus on cognitive aspects, a productive disposition is the affective strand of MP. Productive dispositions can be observed through students' engagement in solving mathematics tasks (O'Connor, 2023).

The five strands of mathematical proficiency have been adapted and developed in many countries. The new Australian mathematics curriculum implemented in 2013, has adapted and adopted the four strands of Kilpatrick et al. (2001) as proficiencies to emphasize the breadth of mathematical abilities that students need to acquire through their learning. The four Australian proficiency strands are understanding, fluency, problem-solving, and reasoning (Groves, 2012). Meanwhile, Singapore's mathematics curriculum framework places problem-solving at the center of mathematics learning, with concepts, processes, metacognition, attitudes, and skills placed around the sides of the pentagon. Teachers can measure students' mathematical proficiency by giving them mathematical problems (O'Connor, 2023).

2. Method

This is qualitative research with a case study design. Qualitative research was chosen because it is suitable for exploring group perceptions, beliefs, and experiences (McDuffie & Scruggs, 2008). Meanwhile, case studies can provide detailed and in-depth analysis and can make an important contribution to educational development (Bassey, 1999; Nieveen & Folmer, 2013). This research was chosen to investigate student and teacher perspectives regarding

AL barriers to developing VI students' MP.

2.1 Research Subject

This research involved nine VI students and seven mathematics teachers at an inclusive Senior High School in Yogyakarta, Indonesia. The participants were selected using purposive sampling. The VI students consisted of four low-vision and five totally blind aged between 16 and 18 years old. The VI subjects as research subjects are listed in Table 1.

Table 1. VI Students as a Research Subject

No.	Initial Name	Gender	Grade	VI Category
1	AL (S1)	F	X	Low Vision
2	WDA (S2)	F	X	Low Vision
3	FMSN (S3)	F	XI	Totally Blind
4	FAR (S4)	F	XI	Low Vision
5	IK (S5)	M	XI	Totally Blind
6	IM (S6)	M	XI	Low Vision
7	NK (S7)	M	XI	Totally Blind
8	WIM (S8)	M	XI	Totally Blind
9	NES (S9)	M	XII	Totally Blind

Meanwhile, the teachers consisted of seven mathematics teachers with between 1 and 15 years of experience assisting VI students in inclusive classes. Four teachers are beginner teachers with less than five years of teaching experience. All teachers had a bachelor's degree in mathematics education and did not take special needs education classes during their bachelor's degrees. Mathematics teachers as research subjects are presented in Table 2.

Table 2. Mathematics Teacher as a Research Subject

No.	Initial Name	Gender	Subject	Experience
1	SH (T1)	F	Math	< 5 years
2	WO (T2)	F	Math	< 5 years
3	L (T3)	F	Math	< 5 years
4	S (T4)	F	Math	< 5 years
5	HR (T5)	F	Math	5 – 10 years
6	TY (T6)	F	Math	> 10 years
7	NK (T7)	F	Math	> 10 years

2.2 Instruments and Procedures

This case study used semi-structured interviews to collect data. Semi-structured interviews were chosen because of the flexibility to add questions during the interview and provide more in-depth data (Creswell, 2007). Interviews were conducted alternately for each subject. The interviews took place within 20 to 30 minutes via face-to-face, telephone, or voice notes. The key questions have been evaluated by three experts.

2.3 Data Analysis

Data were analyzed using the Bogdan and Biklen approach by reducing data, categorizing the data into themes, and then making conclusions as results (Bogdan & Biklen, 1998). A member-checking strategy was used to ensure the credibility of the research(Creswell & Miller, 2000). Meanwhile, to ensure transferability and confirmability, the researcher provided a detailed description of the data collection procedures, instruments, and analysis (Algolaylat et al., 2023). Furthermore, to show dependability, the researcher conducted an internal audit of the entire research process.

3. Results

AL barriers to developing MP from the perspective of VI students and mathematics teachers are categorized into three themes: (1) human side barriers, (2) environmental barriers, and (3) technology and learning media barriers. The aspects of each category were inspired by Mogavi et al. (2022). In detail, research findings can be described as

follows.

3.1 Human Side Barrier

From the VI students' perspective, the human side barriers can be categorized into three themes: (1) affective barriers, (2) cognitive barriers, and (3) teaching barriers. The most frequent barriers explained by VI students include their lack of confidence in their mathematical abilities. In addition, the majority of students expressed that mathematics learning occurred too quickly, making it difficult to follow. Detailed research findings are presented in Table 3.

Table 3. Human Side Barrier from VI Students' Perspective

VI Student Perspective	Aspect
Not sure about mathematics learning abilities	Affective Barriers
Embarrassed to participate in the discussion process	
It is difficult to understand mathematical concepts, especially in geometry and graphics in algebra.	Cognitive Barriers
The learning process mostly provides teachers' explanations followed by task	Teaching Barriers
The learning process and explanations are too fast, so it is difficult to follow	
The teachers' descriptions for material related to figures and graphics are not detailed and specific	
The assessment process is not yet fully accessible for VI students	

From the perspective of mathematics teachers, the human side barriers can be categorized into two themes: (1) affective barriers and (2) teaching barriers. These barriers are mostly found in novice teachers with less than five years of experience in inclusive classes. The most frequent barriers were a lack of confidence in facilitating VI students in inclusive classes and difficulties in time management. The detailed teachers' perspectives are presented in Table 4.

Table 4. Human Side Barrier from Mathematics Teachers' Perspectives

Teacher Perspective	Aspect
Uncertainty can facilitate VI students optimally in inclusive classes	Affective Barriers
Worried about wrong attitude towards VI students in inclusive classes	
The traditional method is considered the easiest and most effective method for developing MP	Teaching Barriers
Limited communication skills between teachers and VI students	
Difficulties in time management, so there is not enough time for AL	

Based on the description, the human side barriers explored by VI students and teachers are almost similar. Both of them revealed that they felt low confidence in affective barriers. S2 expressed, "I find it difficult to understand the material, especially those related to graphs and images. This causes me to be unsure of my math skills". Apart from that, time management during the learning process is also being barrier that many explain. T3 stated, "Several times I faced a lack of time during the learning process in inclusive classes because I had to repeat the explanation several times".

3.2 Environmental Barrier

The second theme is environmental barriers. There are two main barriers in this theme: (1) classroom barriers and (2) social barriers. Classroom barriers relate to physical conditions and classroom conduciveness to support AL. Meanwhile, social barriers relate to interactions between VI students and sighted students or teachers during the AL process. The barrier that was most frequently explored by VI students are class was not conducive to AL and they were not allowed to participate in group discussions or group projects. Table 5 outlines the VI students' perspectives regarding environmental barriers.

Table 5. Environmental Barrier from VI Students' Perspectives

VI Student Perspective	Aspect
The classroom is not conducive to AL	Classroom barriers
Sighted friends sometimes get noisy during the discussion process, it causes disrupting their focus on learning	
Sighted friends do not respond when VI students face difficulties in learning	Social barriers
Ignored by sighted friends in class while studying	
Not allowed to take part in group discussions or group projects	

The environmental barriers expressed by mathematics teachers include sighted students making noise during AL. It causes the AL not to be optimal because teachers need to manage classes. The other barrier is the limited abilities of teachers and sighted students to help VI students in inclusive classes. The limitations of communication skills sometimes make them ignore VI students to participate in discussions. Table 6 describes environmental barriers from the mathematics teacher's perspective.

Table 6. Environmental Barrier from Mathematics Teachers' Perspective

Teacher Perspective	Aspect
Sighted students make noise during the mathematics learning process	Classroom barriers
Limited communication skills of sighted students with VI students	Social barriers
Not all sighted students have the skills to assist VI students during the learning process	
Limited communication skills of novice mathematics teachers with VI students	

Based on the description, the environmental barriers explored by VI students and teachers are almost similar. Both of them revealed that classes are not conducive to the learning process. This condition is caused by sighted students in the class making noise. One of the social barriers explored by VI students is they're not being involved in the group project. The teacher explained that sighted students had limited communication and assistance skills to help VI students. This is predicted to be the reason they do not allow VI students in group projects. S6 revealed, "In class, VI students often sit next to each other. It was difficult to ask sighted students if I faced some barriers when learning mathematics. In addition, in group projects, I am not given part of the task to complete."

3.3 Technology and Learning Media Barrier

The third theme explored in this research was technology and learning media barriers. The barriers are (1) the availability of technology and learning media and (2) accessibility to used technology and learning media. Table 7 describes the barriers to technology and learning media from VI students' perspectives. The findings show that the availability of technology and learning media is still limited to supporting AL in increasing students' MP in inclusive classes.

Table 7. Technology and Learning Media Barrier from VI Students' Perspective

VI Student Perspective	Aspect
The availability of learning media for VI students' hands-on activities is limited	Availability barriers
The learning media is not easy to use	Accessibility barriers
Orientation towards technology and learning media is not optimal	

Mathematics teachers explore the availability of mathematics learning media to support AL is still limited. In addition, teachers' training in the use and development of technology and learning media is still limited. Table 8 describes the barriers to technology and learning media from mathematics teachers' perspectives.

The results of comparing the barriers faced by VI students and teachers regarding technology and learning media show that they agree the availability of learning media for VI students' hands-on activities is limited. S1 said, "For materials that use graphics, the media is still limited, and teachers also have difficulty in explaining to VI students." Teachers explain that limited time and high costs for developing technology and learning media are the cause of this condition. T6 explained, "The media available at school for VI students is quite limited. Meanwhile, teachers do not

have enough time to develop media independently. We hope that related parties can provide support, especially to assist in providing mathematics learning media for VI students."

Table 8. Technology and Learning Media Barriers from Mathematics Teachers' Perspectives

Teacher Perspective	Aspect
The availability of learning media for VI students' hands-on activities is limited	Availability barriers
Limited time for mathematics teachers to develop learning media	
High costs for developing technology and learning media	
Teachers training to use and develop technology and learning media for VI students is limited	Accessibility barriers

4. Discussion

In recent decades, mathematics learning has changed to higher standards for students, emphasizing learning strategies that give students opportunities to participate in the active learning process. This type of learning is known as AL, where students are actively involved in constructing their knowledge. In AL, group discussions and simulations are well-known and applied in mathematics classes (Abdel Sattar & Labib, 2019). Implementing AL in the classroom requires a well-designed teaching methodology (Syeda et al., 2020; Weiser et al., 2018). Optimizing AL in inclusive classrooms to develop MP requires the perspectives of VI students and teachers.

This research presents empirical evidence of the AL barriers experienced by VI students and teachers in developing MP in inclusive classes. The findings showed that VI students felt unsure of their ability to learn mathematics and embarrassed to engage in discussions. Meanwhile, novice teachers also stated that they were not sure they could facilitate VI students optimally. These findings indicate that VI students and novice teachers have low self-efficacy regarding AL in inclusive classes. Self-efficacy is defined as individuals' beliefs about their ability to carry out future tasks (Bandura, 1997). Self-efficacy is important for successful mathematics learning because it affects students' engagement, effort, and academic achievement (Klassen & Usher, 2010).

The low self-efficacy of novice teachers to implement AL in inclusive classes should be given particular attention. Teachers' self-efficacy influences their orientation towards teaching, their specific behaviors and practices in the class, and the academic achievement of students (Alibakhshi et al., 2020; Han & Wang, 2021). Some other research shows that teachers with high self-efficacy perform much better in managing and organizing the classroom and have higher commitment, enthusiasm, motivation, and resilience (Fathi & Derakhshan, 2019; Zee & Koomen, 2016). Therefore, it is important to improve the self-efficacy of novice teachers and VI students to optimize AL learning to develop students' MP.

Teaching barriers from the perspective of VI students included the learning process being too fast and the learning evaluation being inappropriate. Meanwhile, teachers considered the lack of time to manage AL. All of this indicates that classroom management for developing MP is not optimal. This lack of classroom management allowed for the existence of environmental barriers expressed by the VI students and teachers. Classroom management is one of the main factors for optimizing student engagement, creating a positive classroom culture, and facilitating an optimal learning process (Jones & Jones, 2012). It is claimed to be effective if disruptive situations can be overcome, and classes become conducive to learning activities (Skiba et al., 2016). In classroom management, teachers need to establish good personal relationships during learning activities so that students feel comfortable and enjoy the learning process (Booker & Lim, 2018; Cheung et al., 2017). In addition, teachers need to provide feedback on their students' work during evaluation. Their ability to provide feedback can encourage students to improve their learning, especially when completing tasks (Endedijk et al., 2014).

The third barrier discussed in this research is the limited technology and media used to support the learning process. VI students and teachers responded with a similar perspective regarding this barrier. VI students need this learning media to develop MP, especially related to geometry, graphs, and other visual materials. It is important for VI students' hands-on activities because the brain's ability can process information optimally when many senses are involved (Shams & Seitz, 2008). This technology and learning media are one of the primary keys in AL to ensure that students are not passively listening. Multisensory media in mathematics learning, such as tactile media, can be useful not only for VI students but also for all students in inclusive classrooms (Hayes & Proulx, 2023).

In terms of technology and learning media barriers, teachers stated that training to develop and use technology for AL learning to improve MP for VI students was limited. The majority of mathematics teachers in this research had

not undertaken special needs education courses during their undergraduate degrees. In addition, training regarding disabilities, especially VI, and how they develop, is limited and not conducted continuously. This suggests that teachers' training to conduct AL in inclusive classrooms needs to be conducted consistently and continuously. Previous research also revealed that teachers should receive training to enhance their knowledge and skills in teaching VI students (Hayes & Proulx, 2023; Maguvhe, 2015). This is not only related to technology and media learning, but classroom management also needs to be trained to address the various barriers mentioned by VI students and teachers.

The discussion shows that the comparison of barriers to AL explored by VI students and mathematics teachers is almost similar. In general, this research presents empirical evidence regarding the barriers faced in AL according to the perspectives of VI students and teachers. This is important as empirical evidence to strengthen previous research. For example, previous research revealed that active learning problems were experienced by many students (Mogavi et al., 2021). This research shows that teachers in the classroom also faced many barriers regarding AL. Despite this, previous research has revealed barriers to AL in regular schools, universities, and online classes (Børte et al., 2023; Mogavi et al., 2021) and has not revealed much in inclusive classroom settings. The findings contribute to developing inclusive education practices, especially for VI students. Finally, this research not only helps researchers and practitioners understand the barriers to AL in inclusive classes but also points out unmet needs as an opportunity for future research and design.

5. Conclusion and Recommendation

This case study aimed to explore the perceptions of VI students and mathematics teachers related to AL barriers in inclusive classrooms to develop MP. The research identified AL barriers to developing MP from the perspectives of VI students and teachers, categorized into three themes: (1) human side barriers, mainly students' lack of confidence in their abilities and novice teachers' lack of confidence in facilitating VI students. This indicates low self-efficacy; (2) environmental barriers, mainly related to discrimination and limited communication skills; and (3) technology and learning media barriers, mainly related to limited learning media for VI students' hands-on activities.

This research recognizes some limitations related to the research subjects. The researcher has attempted to ensure the diversity of participants' backgrounds, but there may still be some bias. For example, all the teachers involved were female and the majority had less than five years of teaching experience. Future research needs to explore with more diverse participants. Today's teachers should be future-oriented and innovative in learning and curriculum that focuses on student-centered learning. The education system should facilitate the needs of VI students and adjust them to provide better education services. Future research is required to develop an AL model to develop an MP for VI students in inclusive classes. This is expected to be a concrete solution for making mathematics learning accessible for VI students. In addition, future research should explore the perspectives of students with other disabilities related to mathematics learning. This will lead to better inclusive mathematics learning practices.

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Authors contributions

All the authors contributed equally to the study. Sumbaji Putranto, M.Pd. was responsible for study design, data collection, and drafted the manuscript. Prof. Dr. Marsigit, M.A. was responsible for revising the study design and manuscript. Dr. Dra. Elly Arliani, M.Si. was responsible for data analysis and revised the manuscript. All authors read and approved the final manuscript.

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