Exploring Learning Disability Students Experiences in Using AR Technology in Physical Education

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Abstract: In this century, Augmented Reality (AR) is a "reality" technology that has begun to be integrated into the school curriculum and subjects. As one of the learning strategies, the goal is to help increase student learning motivation, the effectiveness of learning activities, and much more. Unfortunately, only a few studies incorporate AR into teaching and learning activities for Adaptive Physical Education (APE) disciplines. Many types of disabilities, including learning disabilities (LD), can be found. Just like their peers, children with learning disabilities are intelligent. However, because of an impairment in their physical, mental, behavioral, or sensory abilities, they need adaptive learning activities that are as similar to the surroundings of children with special needs as possible to help them develop their abilities (Sukriadi, 2021). This study will explore how AR technology affects PE learning experiences for students with learning disabilities (SLDs). This study will use a qualitative exploratory case study to collect comprehensive data for each students learning experience using pre-interviews, observations, and in-depth interviews as the research instruments during PE class. The results of this study are expected to provide an overview of future PE subjects where technology has started to be incorporated and can be used as a new learning medium for teachers and students to create new learning experiences. It will also offer research opportunities for researchers and developers to enhance this application further.

Keywords: Augmented Reality, Physical Education, Student with Learning Disabilities, Mobile Application, Learning Strategies

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Introduction

Technology in education has increased significantly over the past decade (Li et al., 2020). Educators can now employ technology to improve the learning experience for students, supported by the development of digital technology and the Internet (Mohalik & Sahoo, 2020). There are many ways that technology can be applied in

education, which can be used as an online learning platform (Abuhassna et al., 2020; Agormedah et al., 2020; Z. Y. Liu et al., 2020; Mokmin & Masood, 2015): learning management systems (Irfan et al., 2020; Putri & Sari, 2020): educational apps (Poláková & Klímová, 2019; Widyaningrum et al., 2020): and Digital textbooks (Cheng, 2020; Mahdy, 2020). Augmented Reality (AR) is one of the technologies that can be implemented as an educational app that is now being applied worldwide in educational technology to enhance help in teaching and learning processes (Mokmin, 2020). It also suggests that there has been ongoing interest in this topic, as evidenced by the growing number of related articles. However, A total of 174 studies used AR technology in the field of education shows the highest use of AR in education is applied to mathematics and statistics, the second is biology, and the third is manufacturing, construction, and engineering education (Ajit et al., 2020; Garzón et al., 2019; Saidin et al., 2015; Sirkaya & Alsancak Sirkaya, 2018). The results also showed that there was a lack of research on the use of AR in physical education.

Physical education is more than just a game or a recreational activity that gives people pleasure and comfort. It is the public face of education and shares the same goals as education. Physical education should be viewed as one of the fundamental components of the educational curriculum. It makes numerous contributions to the overall experience of students in schools, and encouraging students' physical and mental well-being is one of the most important (Harris & Cale, 2022). According to Caspersen et al. (1985), Physical Activity (PA) is any skeletal muscle-driven body movement that requires energy expenditure. Most children learn about the importance of PA in PE classes (Cheung, 2019). Physical activity has a favorable influence on children's physical and mental functions, and it is also significant in terms of risk factors for lifestyle-related diseases that are being discovered at a younger age, such as overweight/obesity and type 2 diabetes (Berman et al., 2012). However, the right kind of physical activity can be challenging for children with disabilities, whereas PA is crucial for their health development (Boman & Bernhardsson, 2019). Úbeda-Colomer et al. (2019) state that people with disabilities are commonly hindered from engaging in physical activities at all levels of society due to their health state and associated challenges such as discomfort, weariness, and a lack of energy. This is one of the challenges faced by people with disabilities in carrying out physical activities.

Individuals with Disabilities Education Act (IDEA) defines "learning disability" (LD) as "a specific disorder in one or more areas of psychological processes involved in understanding and using spoken or written language, resulting in deficits in the ability to listen, think, speak, read, write, spell, or do mathematics," but it excludes learning issues caused by sensory disorders, emotional disturbance, intellectual dissonance, or other conditions (U. Muktamath et al., 2022). Naset (2018) defined learning disability as a group of disorders that affect people's capacity to interpret what they see and hear or connect information from different brain sections. These limitations can manifest in various ways, including specific difficulty with spoken and written language, coordination, self-control, or attention. These challenges can extend to education and impair learning to read, write, and do math. Physical education and health are two related aspects, and they are two sides of one conn (Harris & Cale, 2022). Health is an essential component of physical education and health, which are both ways of achieving high levels of health.

Adapted physical education is a subset of physical education created to provide programs for students with special needs (Abdoellah, 1996). According to Hendrayana (2007), adaptive physical education is an individualized program incorporating physical activity, movement fitness, fundamental movement patterns and skills, swimming skills, dancing, and solo and team sports games developed for people with impairments. According to Putra (2019), adaptive physical education has several purposes:

- To assist students in improving conditions that can be improved.
- To assist students in protecting themselves and any conditions that may affect their condition by participating in certain physical activities.
- Provide children with disabilities the opportunity to learn about and participate in various sports activities.
- To assist students in making social changes and developing self-esteem.

However, sports learning should be tailored to each child's demands and degree of specificity to meet the physical and mental health needs of children with disabilities (Winnick et al., 2017). According to Jalip (2018), various factors inhibit the learning process in adaptive PE classes; Teachers rarely use fun teaching methods; Teachers rarely bring media or learning tools into the classroom; Learning materials that are not tailored to children's abilities, although the learning process of motion for children with disabilities necessitates a special program tailored to their level. In Malaysia, due to ambiguous regulations, a lack of human resources, and inadequate special education facilities, it has been observed that children with disabilities do not fully realize their constitutional right to an education (Ozel et al., 2017). In their research on Special Education in Malaysia, Abdul Nasir and Erman Efendi (2016) noted that these programs face a number of challenges, including a lack of facilities, preparation, resources, and instructional materials. Studies by Riyadi (2017) found that the obstacles faced by children with learning disabilities in conducting physical education activities are; weak thinking power and adaptive behavior, which results in their ability to capture responses that are not well coordinated, requiring a long time to receive teacher explanations. However, in traditional physical education, the instruction does not usually allow students to fully comprehend correct motions due to their viewing angles or teachers' quick demonstrations (Liang et al., 2023). Furthermore, because the teacher cannot provide individual coaching to many students, beginners cannot recognize the faults in their activities (Papastergiou & Gerodimos, 2012).

Augmented Reality in Physical Education

With many uses in many industries, including education, augmented reality (AR) has emerged as a promising technology (Khan et al., 2019). Integrating augmented reality (AR) into physical education classes was relatively new (Mokmin & Rassy, 2022a) It is crucial to remember that technology and teaching methods can advance quickly. Its inclusion in physical education lessons can potentially improve learning opportunities and student engagement (Guerrero et al., 2020).

Table 1. The use of augmented reality in physical education

Authors	Purpose	Results
(Liang et al., 2023)	To investigate the incorporation of information technology into physical education and use augmented reality (AR) as an auxiliary tool to examine the impact of this teaching style on the learning motivation, knowledge, and learning behavior of beginning runners.	The study's findings are as follows: First, the experimental group (using AR) outperforms the control group (video) in motor skill learning. The experimental group also has stronger motivations and outperforms the control group in motor skills, and the experimental group has a more favorable attitude towards and acceptance of the instructional materials.
(Y. Liu et al., 2022)	To analyze the impact of instructing using more realistic physical education techniques for developing and acquiring spatial orientation compared to traditional exhibition instruction.	The AR training method is effective, especially for improving student participation in sports and instructing schoolchildren in advances in physical education.
(Chang et al., 2020)	To validate the impacts of different difficulty levels on instructional materials and the effects of learning outcomes, motor skills, and learning motivation with AR-assisted teaching	The findings from the study suggest that AR-assisted learning with the 3D model improved learning and performed well for more challenging motor skill acquisition rather than video learning.
(Guerrero et al., 2020)	To compare the impact of augmented reality training in physical education for developing and acquiring spatial orientation to more traditional training based on the display approach.	It has been proven that the augmented reality teaching approach is effective in teaching high school students, in physical education subjects, particularly in the acquisition of spatially oriented knowledge.

Several articles have examined the use of AR technology in physical education subjects, as seen in the table above. The results show that using augmented reality to teach physical education is helpful, especially for helping students learn spatial concepts (Guerrero et al., 2020); the use of AR technology also increases motor skill learning, motivation, more favorable attitude toward the adoption of the educational materials (Liang et al., 2023); using the AR training method works well too for increasing student engagement and educating students on the latest developments in physical education (Y. Liu et al., 2022); Lastly, it was shown that AR-enhanced learning and performed well when learning more difficult motor skills. According to (Garzón, 2021) research, the future route of AR research in education is to use AR in learning environments populated by students with

special needs. However, Mokmin and Rassy's (2022b) study found that AR technology in adaptive PE is still lacking.

Due to the lack of learning facilities and material instructions for teaching children with disabilities, this research will try to use augmented reality technology as a learning strategy in physical education classes for learning disability students as an assistive tool in learning. The research questions to be answered in this study are:

1. What problems are faced by learning disability students in the traditional PE class?
2. How are the learning experiences of students with learning disabilities when using AR as an assistive learning tool in PE classrooms?
3. What are the results of student's movement abilities before and after using AR in the PE class?

Methodology

This paper uses qualitative case study methods with ten learning disability students in one of vocational senior high schools in Malaysia as participants. The procedure is divided into three stages: before intervention, the intervention, and after intervention. Before the intervention, students will be given an AR module (as a representation of the textbook that they usually use in the classroom when learning) to do a pre-test to try demonstrating the exercise movements in the module based on their understanding of the module. After they do the pre-test, a pre-interview will be conducted to find out the current situation in the traditional PE class according to the student's experiences.

After that, the intervention will be carried out (students will learn PE in the classroom with AR as an assistive tool); while the learning process takes place, observations will be carried out by teachers and researchers. Then after the learning process is done, students will be asked to do a post-test and in-depth interview. The data obtained will then be analyzed using thematic analysis. Meanwhile, the students selected to be participants in this study were required to be enrolled in a physical education class, a learning disability student with no difficulty in movement ability, visual problems, or physical problems, and fluently communicate with the Malay language.

Learning Materials

During this research, students will get the AR exercise applications and AR modules as learning materials in the PE classrooms. The content in the module is adapted from books on physical education for special education, and the exercises chosen have been adapted to the learner's needs and abilities. The picture below is an AR module used as a textbook representation that students usually use in class and as a marker used to trigger 3D objects in the AR application to come out. As explained earlier, this module has been adapted from PE textbooks. Also, the exercises selected have been adapted to the needs and abilities of students.

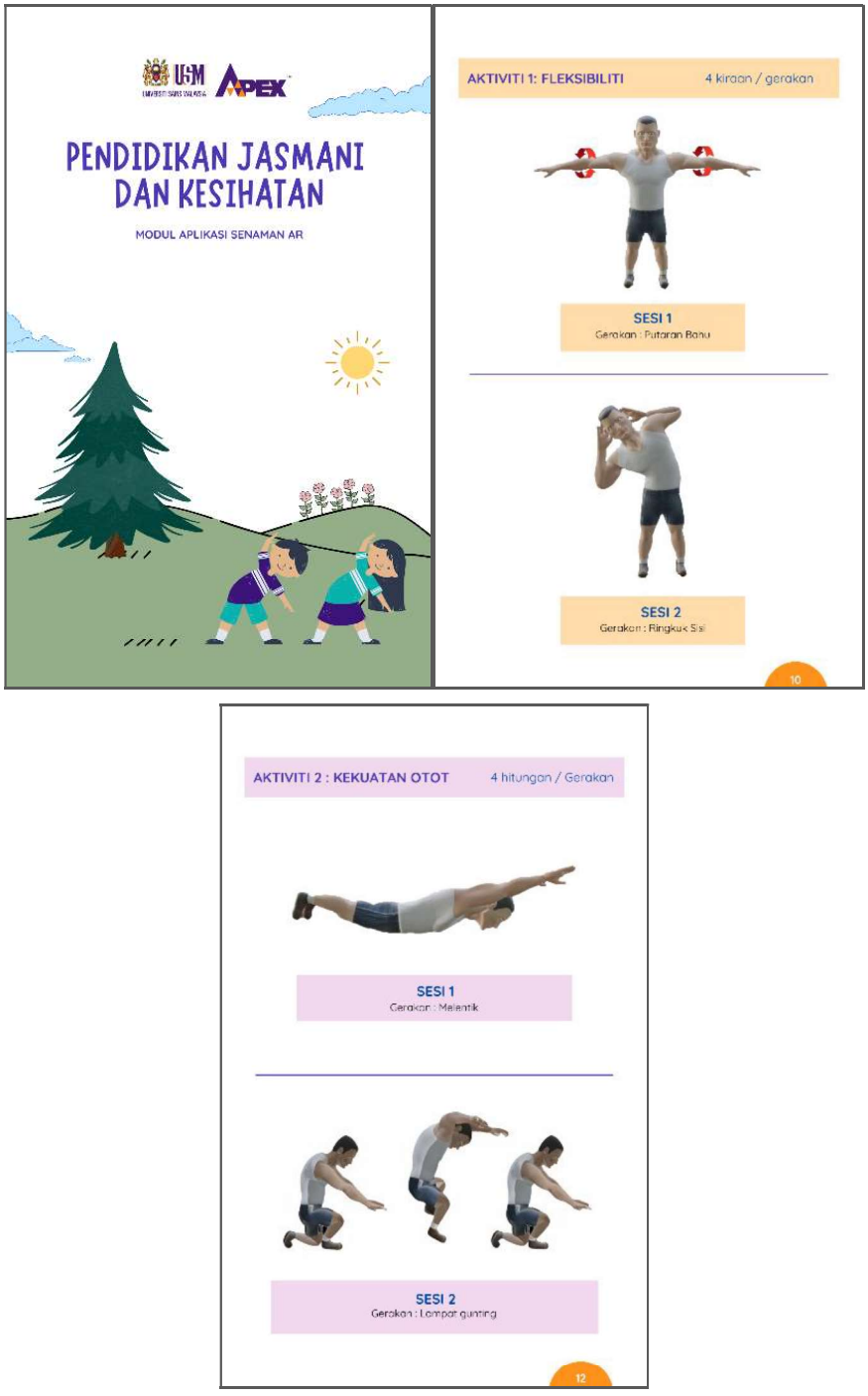

Figure 1. AR module

In this module, there are three chapters, where the first chapter contains balanced food suggestions for students, the second chapter includes suggestions for physical activities that students can do daily, and chapter three contains activity exercises that have been integrated with AR applications. This chapter has three sub bab: flexibility, muscle strength, and muscle endurance. Where in each activity, there are four movement exercises.

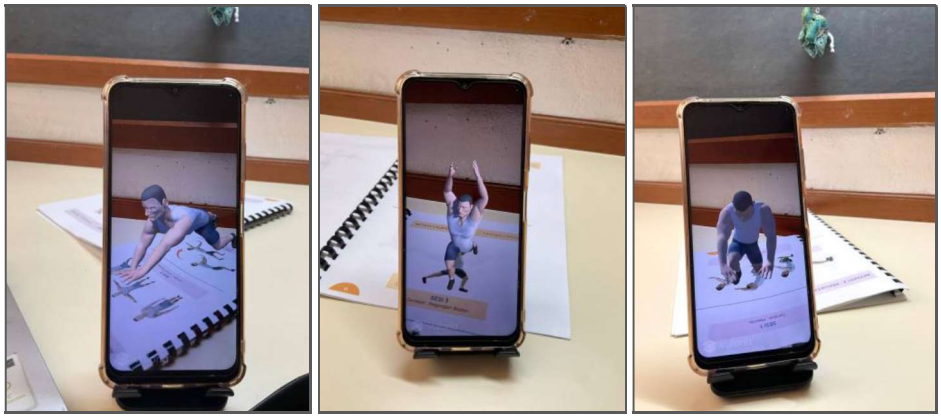

Figure 2. AR exercises App

The picture below is the AR Exercises App used; as seen in the application, no user interface is available to avoid the overload of memory on the students. The application was designed to make it easier for students to use, so students only need to open it before the camera appears. Students need to point the camera to the 2D image on the module they want to visualize. The image in the module will act as a marker that will trigger the animation in the form of a 3D object that will demonstrate the movement of exercises to students.

Results

The figure below shows the results of data analysis using the thematic map to show the relation of each theme. Two main themes exist regarding the student's learning experience in PE classrooms. The first is the student learning experiences while in traditional PE classrooms, and the second is when learning using AR Apps in PE classrooms, and there are sub-themes for each of these main themes.

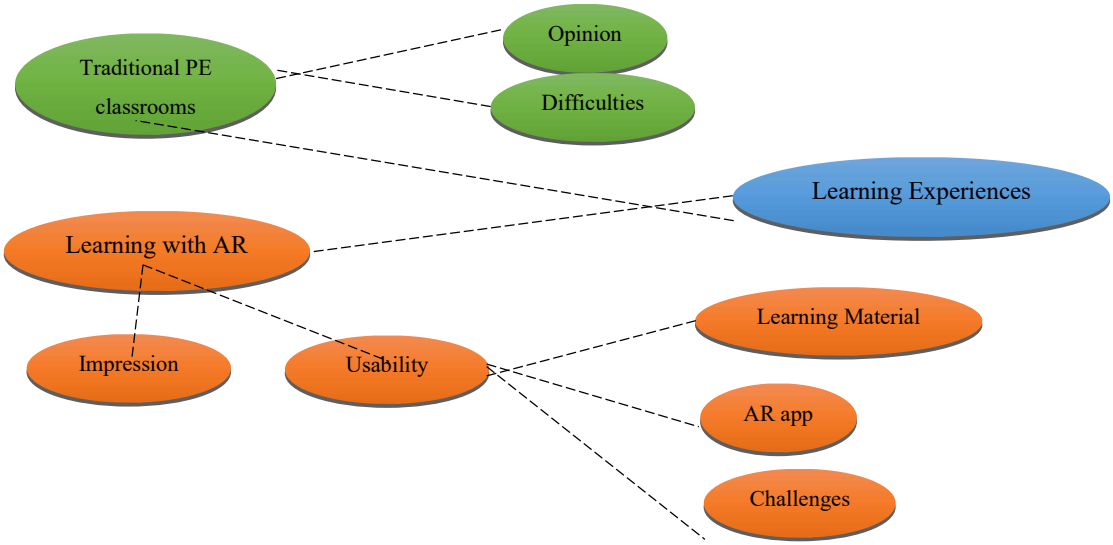

Figure 3. Thematic map

Problems Faced by LD Students in Traditional PE Classrooms.

There are two ways of learning in the PE learning curriculum: when students have to learn in the classroom using textbooks, they will also learn in the field to practice the material they have learned before. The analysis results found one theme about students' learning experiences in traditional PE classrooms with two sub-themes: opinions and difficulties. The first sub-theme describes student's opinions that students felt and experienced during learning in PE classrooms;

- Students said they felt bored when learning PE in the classroom because they were required to sit, write, and read a book. Meanwhile, they prefer to learn PE in the field.
- Students felt happy and enthusiastic about learning PE rather than other subjects because they could do any exercise and sports in the field.
- Students also said PE was good for their health and could release stress when they were tired of studying.

The second sub-theme describes student's difficulties that students experience during learning in PE classrooms;

- The students said that it is challenging to interpret 2D images in physical education textbooks.
- They have difficulty imagining the movement and how to exercise they should.
- Students also felt that reading the exercises movement descriptions in the textbooks and looking at the 2D images was insufficient to understand how the actual movements had to be made.
- Meanwhile, students felt that teachers do not have much time or opportunity to repeatedly show these movements to each student.

LD Student's Experience When Using AR.

After the intervention, in-depth interviews were conducted to know the students' experiences using the AR app. The result shows that there are fifth sub-themes found: Impression, Usability, Learning Materials, AR applications, and challenges exist.

The first sub-theme describes their Impression while using AR as a new technology in their PE classrooms;

- Students said this is a new learning tool since it is their first time using AR technology in their learning.
- They all like using the AR app and feel that learning by using it is fun because it can help them visualize the image on the module since it can show the animation of the exercise movement.
- Students are interested in using AR applications because now everyone uses technology, so this app helps them make their learning easier in classrooms and still up to date.

The second sub-theme describes AR Usability while using it in PE classrooms;

- Students said that by using the AR app and module, they did not need to rely on the teacher when they had difficulty understanding the 2D images (exercise movement) in the module, and they could also study at home.
- Students also said using this application in the classroom would make teaching easier for teachers.

Apart from that, the third sub-theme is the Learning materials which shows the student's impression when using

the AR module in learning;

- Students said that the instructions in the module were easy to understand because it focused on essential descriptions.
- The exercise movements shown by the 2D characters in the module were also easy to understand.
- The overall exercise movement in the module was easy to do.

The fourth sub-theme is the AR Application which shows the use of AR applications on students;

- AR application was easy to use.
- 3D objects used are clear, and the AR app's animations were easy to understand.

The last sub-theme is the Challenging when using the AR Application in the classroom;

- Students said that it was challenging to do the scissor jump movement.
- Students said that several 2D objects were difficult to detect, so 3D objects in the application did not appear immediately, and there were also blinking 3D objects.

LD Students Movement Ability Results

Before the intervention, students are asked to do a pre-test to see their movement ability of students without using the AR app. After learning, students will do a post-test using the same movement ability rubric. Below is a descriptive analysis of students' movement ability's pre and post-test results. The results showed that there was an increase in movement ability from the pre-test to the post-test.

Table 2. Student's movement ability results

	Pre	Post
Sample Size (Students)	10	10
Mean	8.28	9.68

Discussion

From the data collection and analysis results, this study found several difficulties that LD students faced when learning physical education in a traditional classroom. They stated, "It is challenging to translate 2D images from physical education textbooks into a movement for physical activity or exercises". By only looking at the images in the book and reading the explanation, it is considered insufficient by students because some students have difficulty remembering and understanding an instruction. Some students also need repeated explanations or demonstrations from the teacher when learning new exercise movements. This is in line with studies by Riyadi (2017) found that the obstacles faced by LD children in conducting physical education activities are weak thinking power and adaptive behavior, which results in their ability to capture responses that are not well coordinated, requiring a long time to receive teacher explanations. Tommy et al. (2022) found that LD students face difficulties in PE learning are understanding the material and the student interest; meanwhile, the problems teachers face are difficulties in delivering the material and the available learning tools.

With the discovery of several gaps in the pre-interview and after the in-depth interview, it was found that students were very impressed with the use of this technology in their learning and found it interesting since they had never used it in the classroom before. Research by Kraut & Jeknić (2015), which uses Augmented Reality Applications in the Field of Vocational Education and Training, found that students felt using augmented reality (AR) software in the classroom for their lessons wa AR also helps assist in student comprehension by visualizing various physical processes in the learning (Daineko et al., 2020). Then for its use in the classroom, AR can be their learning assistant that can help students and teachers so that they do not need to repeatedly demonstrate the movement of the exercises to each student since some students have a slow response in learning. According to Samuel's (2020) research, AR is one of the assistive technology that can help disabled students with their vision. In line with this research, AR act as assistive technology that helps students visualize 2D image on the module and become the 3D animation that demonstrates the exercise movement to the student.
For the module used, students felt that there were no problems with the content, the text, label, design, or 2d images used, all of which were good. Karamanoli et al. (2016) suggested in their research that the creation of supplemental materials for history and other school subjects taught to students may be the subject of future research. This research followed PE textbooks to create the module and the guideline of cognitive load theory when designing and choosing the content for the module. Similar to the module, the AR app is easy for students to use, and the use of animation helps students understand the movements of the exercises described in the module. Since in the application and module, we do not want to provide too many menus or descriptions to avoid memory overload in students.

Conclusion

This study aims to explore the use of AR technology in PE subjects with learning-disabled students as a learning aid in the classroom. The results show that AR has successfully assisted and helped students understand the 2D image of the exercises movement on the module without reading any longer description byy visualizing the exercises images in the module. Students with learning disabilities usually have a slow response to learning which requires the teacher to repeat in demonstrating the exercises movement to several students. On the other hand, AR also helps teachers minimize the repetition of demonstrating exercise movements to each student, saving teachers time and energy in the classroom. Teachers can focus on other things, such as observing student understanding, instead of repeatedly demonstrating movements to each student because the learning time is less effective if this happens continuously. Moreover, students can also repeat lessons and study independently at home. Using this app as an assisting tool in the adapted PE classroom also increased the students' interest and curiosity. However, this research also finds some limitations; the AR app is only suitable for Android users, with a minimum Android version being 7.0. If installed on a smartphone that has a version below that, several possibilities can occur, such as difficulty detecting the marker (image on the book), a black screen appearing, a line on the screen appearing or objects appearing with imprecision, and the last is that there are difficulties when detecting some markers.

Recommendation

Researchers suggest further research to adjust the availability of AR applications that will be built on the current operating system version at that time so that more users can use them. The second is to make an iOS version of the AR application as well since this app and module have been brought to the technology innovation exhibition, and it was found that many iOS users are also interested in this application. Last, to keep it updated on technological developments, it is recommended that future research be able to build AR applications for children with disabilities that have been integrated with AI and gamification on it to make it more interactive.

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